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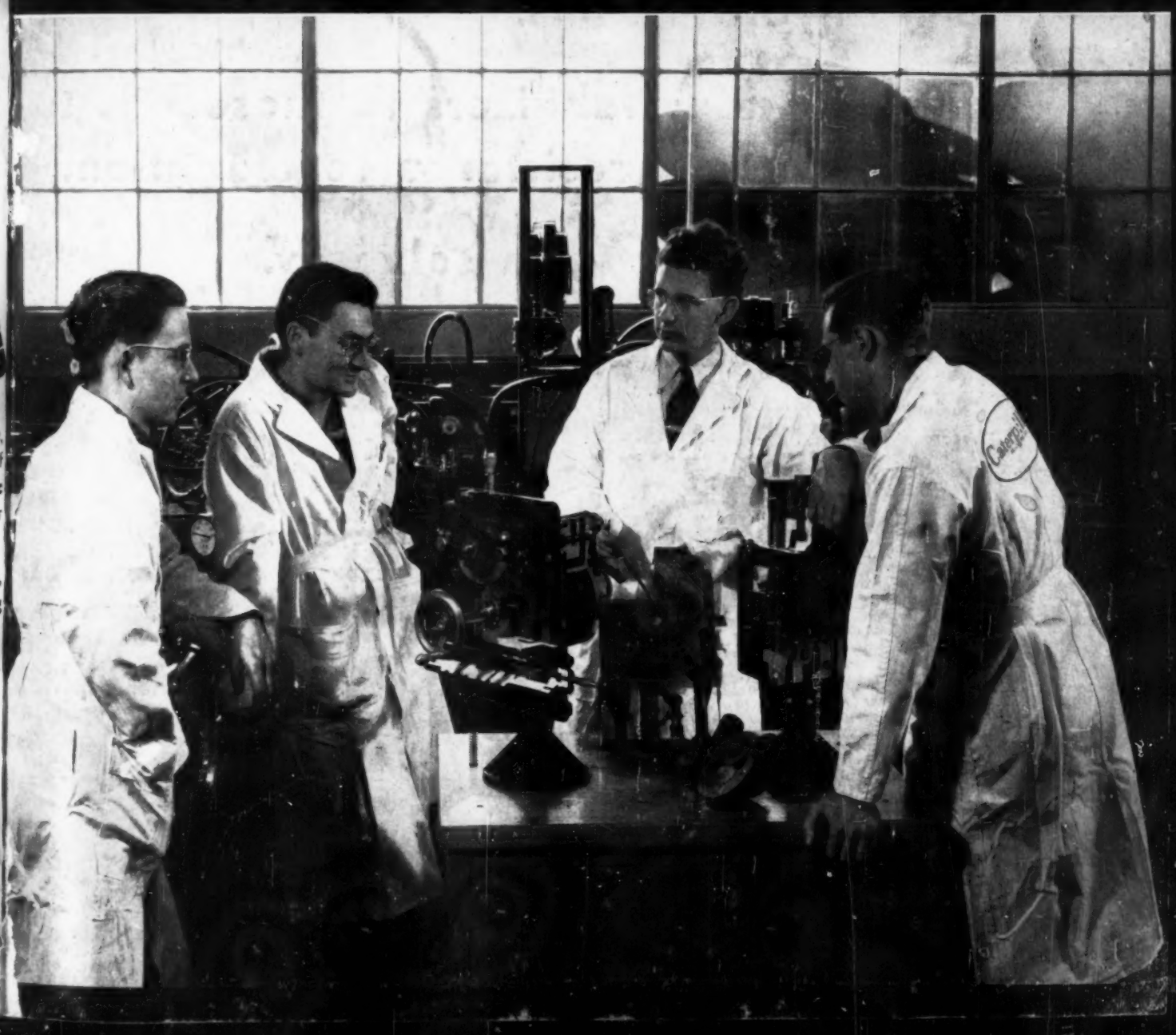

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MARCH, 1948

Vol. 1 No. 2

Applied HYDRAULICS

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FRONT COVER: Instruction in pump construction being given in the hydraulics training program at the Caterpillar Tractor Co. Students are thoroughly grounded in the design and construction of all types of hydraulic units before setting up and operating the equipment. The training program has eliminated cut-and-try trouble shooting, reduced machine down-time and made systematic preventive maintenance a matter of routine.

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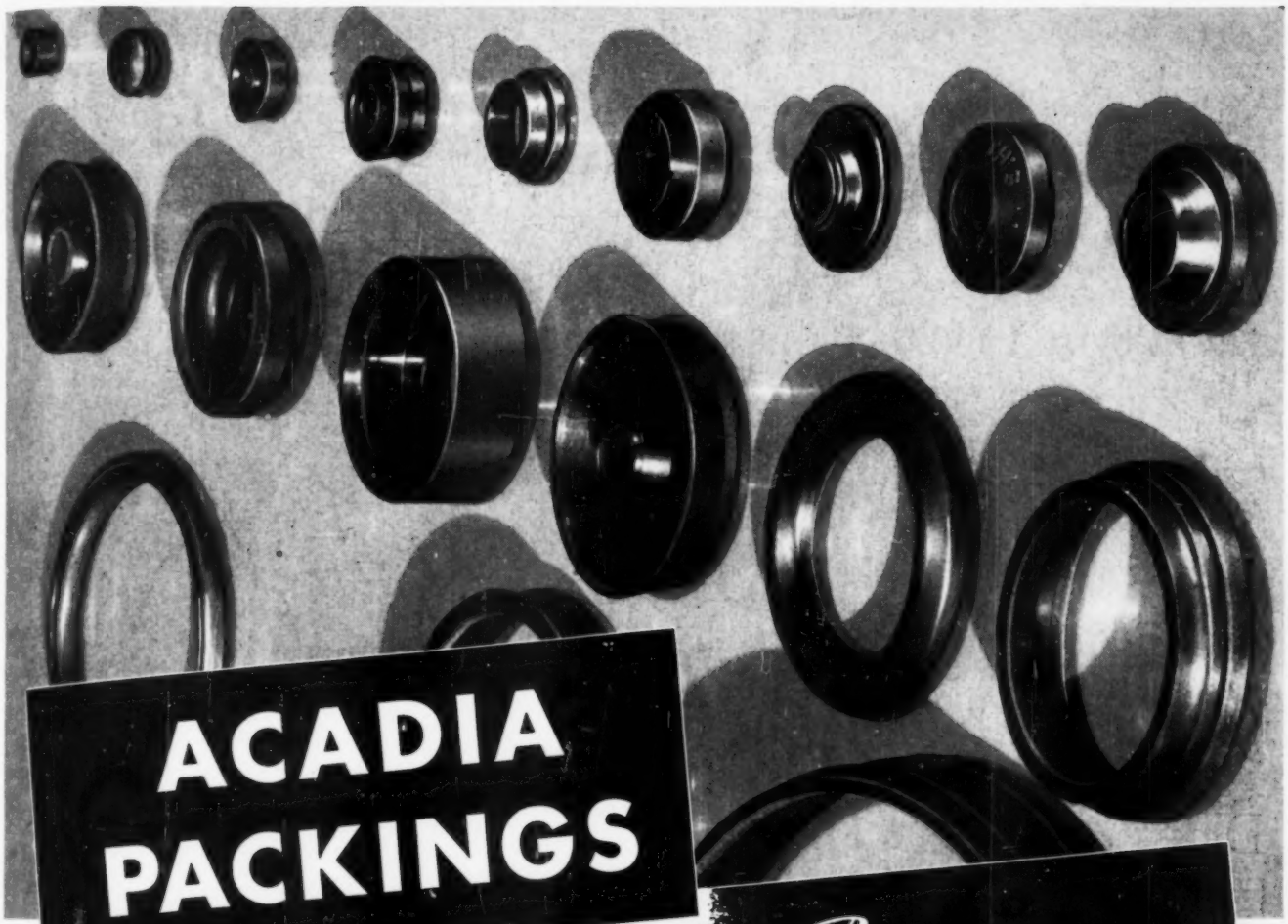

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Process Control with HYDRAULIC CIRCUITS

By H. ZIEBOLZ
Vice President
Askania Regulator Co.
Chicago, Ill.

DURING the past few years there has been more and more of a tendency to combine and to correlate the industrial engineering experience of several fields in order to find broader concepts and common denominators in techniques which had developed in parallel.

For example, during the war the group which developed servomechanisms took advantage of the work previously done by the communication engineers. Industrial control designers established a common terminology with the servo group and with those engineers who, independently, had developed steering devices for ships and automatic pilots for aircraft.

It certainly appears desirable that other technological branches compare notes to determine whether experience gained in one group could benefit another.

In the field of industrial hydraulics there has been such a parallel development in two branches of engineering:

(a) The hydraulic operation of tools; and

(b) The hydraulic control of processes.

The second or control development will be discussed in this paper.

The difference between these two fields is relatively small. In most cases the difference is one of degree or of magnitude of time constants and of energy levels available. However, the process control engineer must frequently work under the disadvantage of vague specifications of the process he has to control and the number of variables he must control is usually greater or their reaction is more complex.

While the variables of industrial hydraulics (applications to tools and machinery) are primarily of a purely mechanical nature, i.e., forces, pressures, strokes, speed, acceleration, masses, etc., we find that the control engineer has to deal with practically the whole field of physical and chemical variables. He starts with the mechanical variables of his colleagues and broadens out into such variables as radiation, consistency, P.H., absolute humidity, color intensity, mass spectrum characteristics and others.

Paper delivered at the Third Annual Meeting, National Conference on Industrial Hydraulics, Chicago, October 16, 1947.

In order to start from a common basis, we will first consider a typical circuit which has all of the basic elements found in both fields.

As an example, we shall take a simple four-way valve which is part of a servo as shown in Figure 1. The purpose of this device is to translate an input signal, stroke (S_1), into a motion or "stroke" (S_2), with an increase of available power and a proportional and duplicable relationship between (S_1) and (S_2).

Components of Circuit

Analyzing the components of this circuit we have:

(a) A source of hydraulic energy, either motor, (M) plus pump (P) or accumulator (A);

(b) A relay (B) which supplies controlled rates of energy;

(c) A power member (Q plus Z) which responds to the energy supply which is modulated by relay (B); and

(d) A device which determines whether the desired relationship between the desired input (S_1) and (S_2) is accomplished, and which is so connected to the relay that the energy distributed by the relay is proportional in magnitude and direction to the error of the desired output.

The relays used in industrial controls usually have an additional specification to fulfill, i.e., that the force to operate them should be as small as possible and that their inertia should be as low as possible.

Three Basic Designs

To accomplish this, three basic designs are used in most applications:

(a) A pilot valve or a number of pilot valves of conventional or slightly modified design in which the static friction of the unit is eliminated by rotation of the sleeve of the pilot. A noteworthy recent example is the hydraulic power unit used in the war in the V-1 and in tank-gun stabilizers.

In Figure 2 sleeves A and B are rotated by gears C and D which, in combination with the center gear U, acts also as a pump for the oil. Depending on the displacement ($S_1 - S_2$) of the two plungers P and Q, pressures P_1 and P_2 are obtained which are approximately proportional to the displacement.

(b) The second type of pilot valve uses the variation of pressure between two orifices which results from a variation of the ratio of the effective areas of the orifices if fluid at constant pressure is supplied to the first of the two orifices.

Figure 3 shows the basic response curve which can be modified by making A_1 an injector and taking P_1 in the throat of the injector, Figure 3b.

If it is desired to obtain zero output of the pressure differential for zero error, two circuits are used.

The one uses a push-pull arrangement as shown in Figure 4.

The second type uses two pistons of different diameters combined and operating in opposition. This is shown in Figure 5.

In the latter case we have the advantage of greater simplicity of the pilot and pay for it by the complication of the power member.

(c) The third basic principle uses reconversion of dynamic energy into static pressure.

In this type of relay a fluid jet impinges more or less on an opening and thereby varies the velocity head pressure as measured in this opening. This arrangement is shown in Figure 6.

An additional advantage of this type of relay is that the reaction forces of a movable jet go directly through the fulcrum of the jet and thus do not produce any additional torque.

While the above designs are modified in various ways without losing their basic character, it might be well to mention two methods employed to modify the output of the relays.

First, let us consider the limitations of a jet as shown in Figure 6. Obviously the capacity of such a jet is limited by the maximum pressure it can handle before the hydraulic fluid starts to atomize (for practical values 200

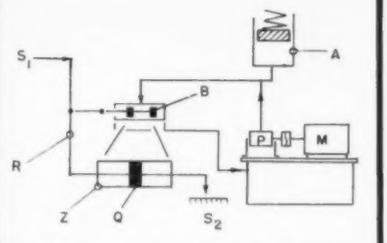


Fig. 1. Four-way valve, part of a servo.

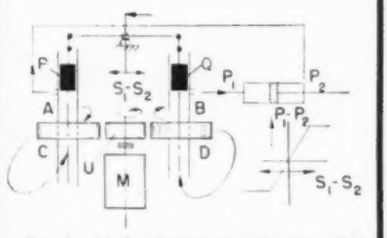


Fig. 2. Hydraulic power unit as used in the V-1 and tank-gun stabilizers.

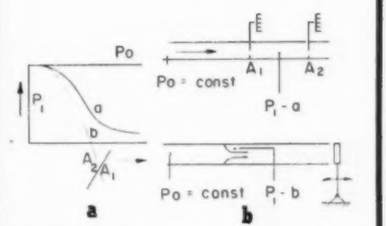


Fig. 3. Basic response curve, which can be modifed by making A_1 an injector and by taking P_1 in the throat of the injector, Fig. 3b.

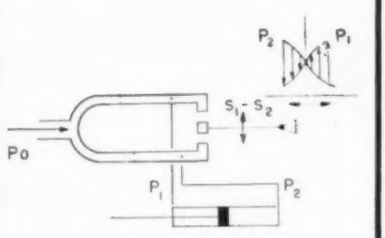


Fig. 4. Push-pull circuit.

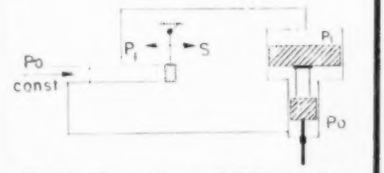


Fig. 5. Two pistons of different diameters combined and operating in opposition.

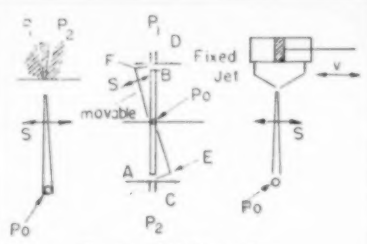


Fig. 6. Fluid jet relay.

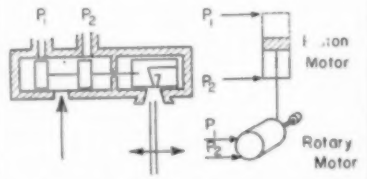


Fig. 7. Jet and four-way valve combination to overcome the limitations of a jet.

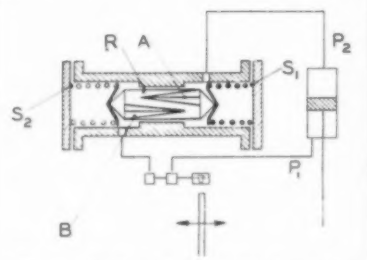


Fig. 8. Design of plug valve for modulating line resistance.

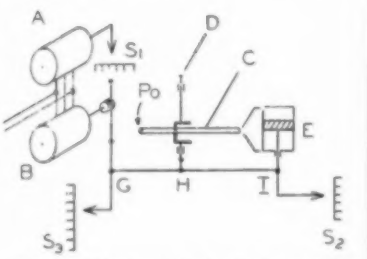


Fig. 9. Relationship of cylinder position and selsyns.

psi supply with a maximum regain of 90 percent in pressure).

Furthermore, there is a limit to the size of the jet even if it takes the form of the nozzle of a pelton wheel.

Typical relays have a maximum of .080 in diameter for the jet (with a maximum volumetric efficiency of about 90 percent).

To overcome these limitations a jet is connected to a four-way pilot valve as shown in Figure 7. By arranging the receiving orifices in a piston and by connecting them crosswise to opposite sides of a cylinder which contains this piston, we obtain a relay which is unlimited in capacity with regard to volume as well as to pressure and yet the fluid coupling by means of a jet prevents any reaction forces from being transmitted to the relay.

If one would like to characterize* the pilot valve as shown, one can do so by providing positive, negative or characterized overlapping of the ports and the pilot piston. However, the production of such valves is a rather difficult job as the total stroke available is usually in the magnitude of a few thousandths of an inch.

*"Characterize" means to establish a desired relationship; e.g., between displacement of the pilot and rate of travel of the hydraulic motor.

To overcome this difficulty, a valve was developed which, inserted into one of the oil lines, modulates the resistance of line in such a way that any desired relation between displacement and speed is obtained. Figure 8 shows the basic design of this plug.

Ports (A) and (B) open more or less as the plunger (R) is balanced by means of springs (S_1) and (S_2) in response to the difference in pressure (P_1-P_2).

By suitably shaping these ports and by the correct choice of the diameter of the plunger (R) and the characteristics of the springs (S_1) and (S_2), any relationship between displacement of the pilot and the rate of flow of the fluid can be obtained.

Quite frequently a problem comes up involving the positioning of a mechanism with a great amount of power while the transmitter is either limited in power or located at a remote point. One solution which was originally developed for a training device uses a selsyn and a jet relay in combination with a hydraulic motor. The selsyn gives displacement but has no power for applying torques. Therefore, a jet relay which gives a variation of oil flow without calling for torque to operate was combined with the selsyn.

By means of a follow-up, a definite relationship between the cylinder position and the selsyns (or synchro) was obtained. The accuracy was .002 (2 per mill). This relationship is shown graphically in Figure 9. The same unit was later modified to position a beam of a charging machine in space by superimposing two components of motion in two axes which were perpendicular to each other.

The additional power was obtained by a multi-piston type hydraulic variable speed gear which was operated by the control cylinder, see Figure 10.

Sometimes even the torque to operate a synchro is not avail-

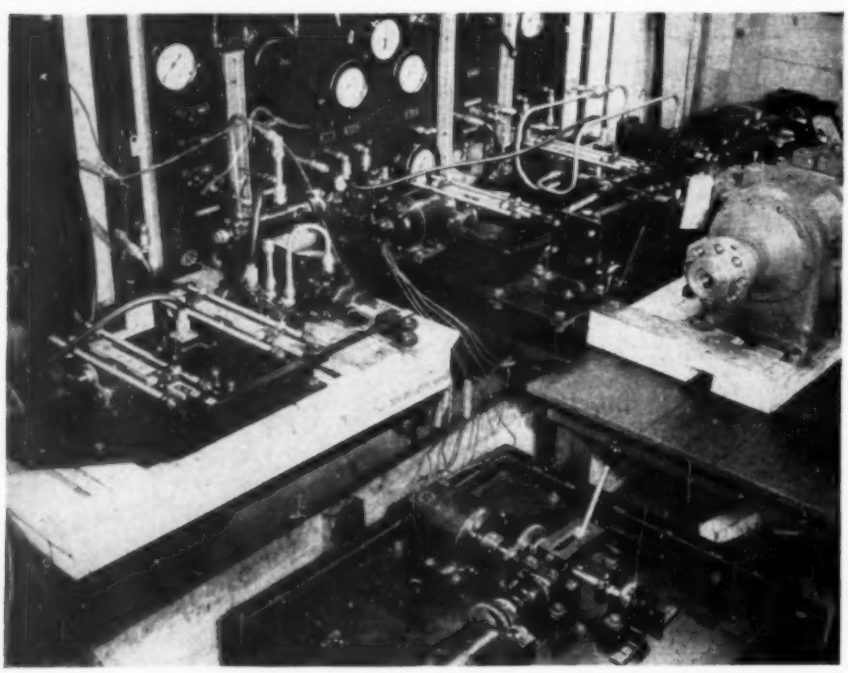


Fig. 10. Two stage hydraulic-electric amplifier.

able. For such cases an air jet follow-up was developed which is shown in Figures 11 and 12.

Air is supplied at a constant pressure through the nozzle (A) and produces a pressure in the nozzle (B). This latter pressure changes if the air stream of nozzle (A) is intercepted by cam (C).

A constant pressure regulator (D) which is connected to (B) is so adjusted that it maintains the nozzle pressure in (B) constant. Therefore, the two nozzles, although not in contact with the cam, follow its contour with great accuracy (.0005 in is typical accuracy obtained by this device).

Obviously such a device lends itself to contour milling or turning or can be modified to follow a three-dimensional cam.

One additional advantage is that the cam can be cut out of paper-thin stock and that they do not wear.

The same principle can be used, for example, to eliminate drill jigs.

If a nozzle is adjusted to a fixed position along an "x" axis and the piston rod carries an interceptor flag, then the piston will move until the air stream is intercepted by the flag.

A number of such nozzles in sequence will thus establish a number of stops which have the advantage that they cannot wear with time (Figure 13).

By adding a second controller along the perpendicular "y" axis, any point in the plane can be reached by coordinating two pairs of nozzles; all that is necessary to do is to connect the two corresponding nozzle pairs to the respective regulators.

To keep such a "pneumatic jig" in stock, it is only necessary to keep spacers for nozzles 1 to 6, which can be rods whose ends are ground to the correct size.

If the stroke of a servo is to be unlimited or if the rotation rather than a translatory movement is desired, the follow-up circuit is slightly changed.

A cam (A), as shown in Figure 14, is rotated by a master shaft (synchro, clock motor or an instrument). Regardless of the original position of the follow-up nozzles, the hydraulic motor (M) will take its correct position (anywhere within 360 degrees of rotation) to satisfy the pressure regulator (R). A possible equilibrium at the intercepting edge (2) is not stable.

We have covered only a few representative applications of hydraulic circuits in the field of process control. Many other hydraulic circuits have been combined with pneumatic, electric and electronic elements to solve various problems of industrial controls.

A complete discussion of these circuits and the interlocks which were developed would go beyond the purpose of this paper, which intends only to call the attention of hydraulic engineers in various fields to a few solutions which have been originally developed to take care of very specific cases.

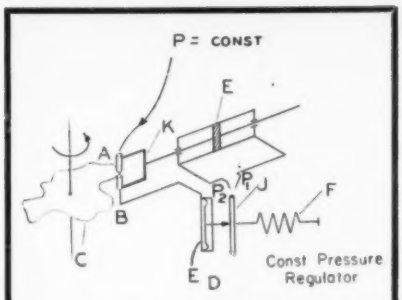


Fig. 11. Air jet follow-up.

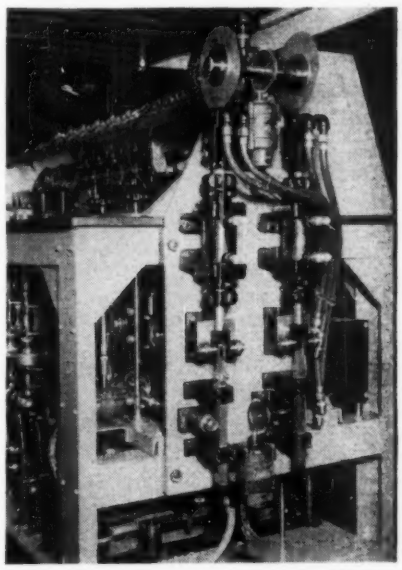


Fig. 12. Use of an air jet follow-up mechanism to introduce a cam motion into a computing device without any load acting on the cam device.

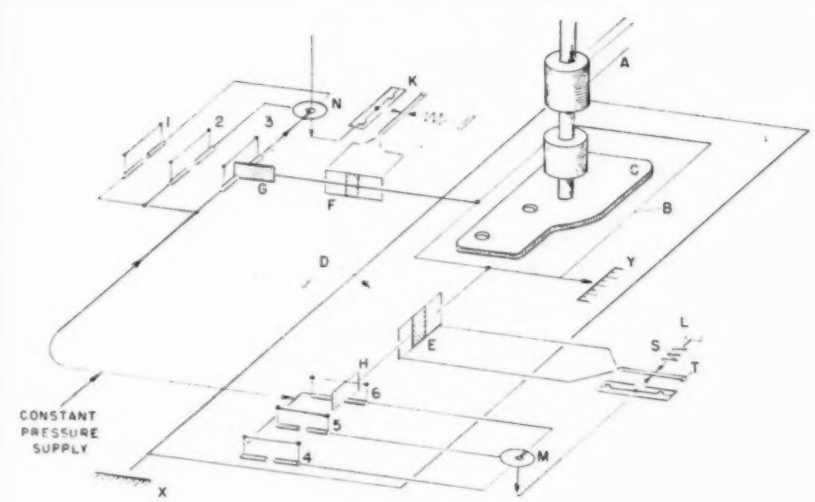
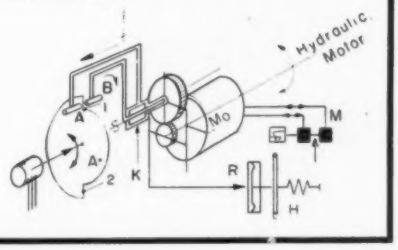


Fig. 13. A pneumatic jig with nozzles in series along both "x" and "y" axes.

Fig. 14. A cam, rotated by a master shaft, in the follow-up circuit, gives unlimited stroke and rotation movement, as compared to translatory movement as shown in Fig. 13.



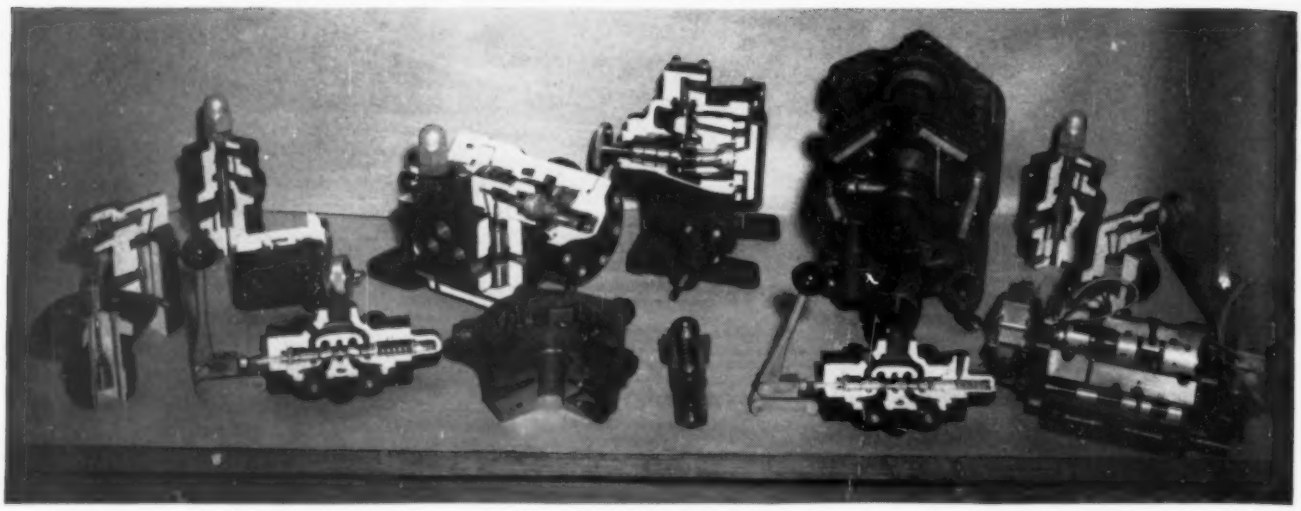


Fig. 1. Cutaway models are used to gain a thorough understanding of the internal construction of pumps, valves and other elements. This knowledge is essential to functional understanding.

Caterpillar's HYDRAULIC Classroom

By PAUL G. GRIEBEL
Supervisor
Classroom Instruction
Caterpillar Tractor Co.
Peoria, Illinois

A Hydraulic training course at Caterpillar Tractor Co. takes the "mystery" out of hydraulic equipment in their shops . . . reduces machine-down time . . . simplifies maintenance and repair work.

THE APPLICATION of the old science of hydraulics to the old art of machine tool building may seem "mysterious" to the uninitiated. It is true that the applications of the science of hydraulics to various machine tools resulted in the mysterious disappearance of numerous gears, cams, levers and shafts. In their place were found pumps, valves and piping through which flowed some strange power transmitting medium. An important result was that a stepless feed and speed arrangement, previously unobtainable with the conventional mechanical linkages, became commonplace.

However, to us at Caterpillar Tractor Co. the "mysterious" was of no value in machine operation or maintenance problems. As normal replacement and expansion witnessed the installation of both standard and special hydraulically actuated and controlled machines, we sought specific information that would be of practical value in maintaining maximum operating efficiency. Occasionally, in seeking such helpful information it was found that a cloak of secrecy was rather tightly maintained about the subject. Text book study was of limited value, particularly for the machine maintenance or repair man, since his interest was in the field of trouble diagnosis and remedy rather than formula derivation and design.

As hydraulic equipment became more and more evident throughout the plant, emergency repairs were necessarily undertaken, sometimes without the benefit of a service representative from the tool manufacturer and often without a trace of reference material. In

such cases, the process of repair was of necessity "cut and try", which proved costly from both the repair and machine-down time standpoints. As a small group of repairmen gradually gained service experience on hydraulic equipment, the maintenance problems of such machines diminished. Only too often a tedious and expensive tear down could have been avoided by a better understanding of basic theory which would have permitted the remedying of many difficulties by minor adjustments or repair replacement. Since misconceptions of purpose and operation of some hydraulic circuit components were practically inevitable, a training program based on the fundamental principles of hydraulics and their application to machine tools seemed in order.

The subject of "Hydraulics Applied to Machine Tools" had been considered as possible material for our 4-Year Machinist Apprentice Course as a result of the interest aroused in these men by their experience of operating hydraulically powered and controlled machines and by their work in assisting machine repairmen.

The 4-Year Machinist Apprentice Course was established in 1925, early in the history of the Company. Table 1 indicates the extent of this program in both the shop and classroom.

TABLE 1

Classroom Schedule

Blueprint Reading and Shop Practice	40 hours
Arithmetic, Algebra and Geometry	48 hours
Engineering Drawing	48 hours
Applied Trigonometry	36 hours
Welding Theory and Practice	24 hours
Job Planning	18 hours
Industrial Physics	72 hours
Materials and Processes	18 hours
Effective Oral and Written Reports	36 hours
Gearing and Indexing	36 hours
Heat Treatment and Metallurgy	48 hours
Production Planning	48 hours
Tool Design	48 hours
Industrial Economics and Company Organization	36 hours
Hydraulics as Applied to Machine Tools	64 hours
Total	620 hours

Shop Schedule

Production	
Drills (Radial and Multiple)	8 weeks
Milling Machine (Hand and Power Operated)	8 weeks
Tool Grinder	12 weeks
Cylindrical Grinder	12 weeks
Hand Screw Machine	12 weeks
Turret Lathe	16 weeks
Semi-Automatic Lathe	12 weeks
Inspection	8 weeks
Tool Room	
Radial Drill	8 weeks
Shaper	12 weeks
Engine Lathe	16 weeks
Grinder	8 weeks
Milling Machine	16 weeks
Heat Treatment	4 weeks
Bench Work	20 weeks
Total	172 weeks

Apprentices, under the supervision of trained instructors in both the shop and classroom, gain theoretical knowledge, as

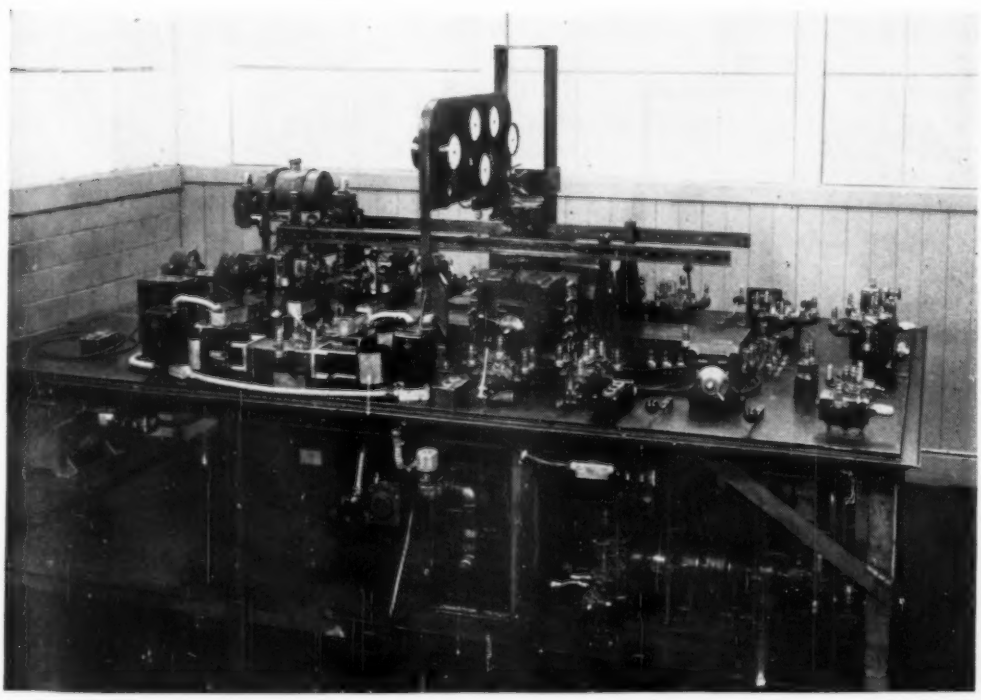


Fig. 2. Actual circuit components are mounted on a demonstration table. A variety of circuits may be developed by connecting components with flexible hose fitted with snap couplings. The table is also used for experimental and development work.

HYDRAULICS APPLIED TO MACHINE TOOLS

Review Questions

Connect the components of circuit #1 and add required equipment that the following action may be obtained:

SEQUENCE OF ACTION

(a) The operator activates the clamping cylinder through a manually controlled four way valve.
(Note: Maximum clamping and brake pressure is 50 psi.)

(b) After the work is properly clamped, the operator manually shifts the directional control spool of the panel to rapid advance position.

(c) The table goes through rapid traverse forward, coarse feed, fine feed portions of the cycle, tripping a limit switch as it comes to rest against a positive stop.

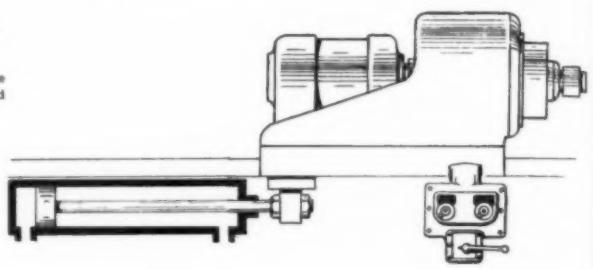
(d) After a pre-determined time delay the power is cut from the spindle motor, the brake cylinder is operated through a solenoid controlled valve, and the reversing solenoid of the panel is energized.

(e) During the traverse reverse phase of the cycle a limit switch is tripped, de-energizing the solenoids.

(f) When the table returns to its original position, a cam lifts the directional control spool to neutral.

Note: Add required cams and dogs to operate panel and limit switches.

REVIEW QUESTIONS SET #16



BRAKE CYLINDER

CLAMP CYLINDER

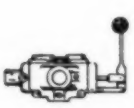


Fig. 3. A typical set of review questions of design nature with components of a circuit which the students connect and add equipment to for obtaining the required sequence of action. Students retain corrected circuits for reference.

well as the practical experience essential to their craft. Both phases, although well established, are flexible and may be altered as the designs of production equipment and methods of manufacturing change.

The need for a training course in the subject of "Hydraulics Applied to Machine Tools" was further emphasized by the Machine Repair and Tool Design Departments through their requests that information on the subject be made available to their personnel.

Program a Joint Project

With this combined interest it was evident that the hydraulic training program was a joint problem of the Machine Repair, the Tool Design and Training Departments. The course was designed to eliminate the "mystery" of the subject, to emphasize fundamental principles, apply careful analysis to both design and repair problems, and study the application of fundamentals to specific jobs. The basic purpose was to assure that the proper operation and care of each machine would be a logical process of following sound procedures.

A plant-wide survey of hydraulically actuated equipment was made and a member of the training staff was selected as instructor. Manufacturers of the hydraulic equipment represented in the plant were contacted and through their courtesies the instructor was extended the privilege of working on assembly and repair of hydraulic equipment at several plants. In addition to first hand information on repair and service, valuable assistance in the field of application was obtained from both engineering and sales departments.

Training aids in the form of cutaway models, multi-colored circuit diagrams, and lantern slides were prepared. Several demonstration tables on which representative pieces of equipment were mounted provided a means of actual demonstration of operating principles. The use of rubber hose and snap couplings facilitated connection of the individual units into various circuits.

The demonstration table (Fig. 2) is an integral unit consisting of an oil reservoir, four styles of pumps, an extensive variety of valves, a vertically mounted cylinder loaded with three hundred pounds of lead, two horizontally mounted cylinders, one acting as a load to the other, fluid motors, gages, and electrical equipment necessary to simulate numerous machine tool circuits. Possible circuit combinations are practically unlimited, ranging from a simple reciprocating action to a sequence arrangement involving clamping of the work, simulated rapid traverse forward of the machine table, feed, dwell, application of a spindle brake, rapid traverse reverse, and unclamping of the work. Auxiliary

(Continued on page 19)

CONTROL OF HYDRAULIC ELEMENTS BY AIR

By
CLARENCE JOHNSON
Consulting Engineer
Orfordville, (Beloit) Wis.

The accuracy of the precision air measuring gage, long established in the instrument field, can be utilized as a means of translating changes in air loading pressure to hydraulic power. Two types of applications are described and illustrated.

GOOD AUTOMATIC hydraulic and pneumatic controls are largely the result of good pilot valve design and good pilot valve design is the result of years of research. In this research which has been carried on by several leading manufacturers of industrial control equipment, the almost limitless accuracy of correctly designed air valves—which is all that air gages are—has played a prominent part. Air valves have been used to control a number of types of hydraulic operations. We will describe and show two representative applications; one, a combined air-hydraulic circuit for precision duplication, the other an air loaded arrangement for remote positioning control.

The first type is a mechanical tie-back; the second is an air loading pressure tie-back.

The first application was pioneered by the Bailey Meter Co. of Cleveland. The production of this company includes such precision elements and parts as Ledoux bells, parabolic displacers, flow nozzles, control valve elements and step shafts.

The long established method of manufacturing Ledoux bells and parabolic displacers was of interest. In boring the Ledoux bells, the tool slide was held against a master cam by weights. The rise on certain parts of the cam contour were abrupt which made it very difficult to follow the cam accurately. Reamers made to the accuracy required were very expensive and short lived.

These devices extract the square root in a standard flow meter and must be accurate and smooth since they rise and fall in a reservoir of mercury. The Ledoux bell, for example, has a parabolic bore about 14 in long varying from 2½ in at one end to 1 in at the other. Polishing is undesirable because the bell will not calibrate if too much metal is removed. Only a few highly skilled men were able to produce these bells and even then bells were often rejected after trial calibration.

It is axiomatic in control work that the sensitivity must be of a higher order (usually ten times) than the limits of tolerance. As there was no equipment on the market that would be adequate for manufacturing these parts, the idea of using the principle of the precision air measuring gage, as a scanning method, was thoroughly explored. It was known that the air flow could be regulated by a stylus position and that a tracer design based on the regulation

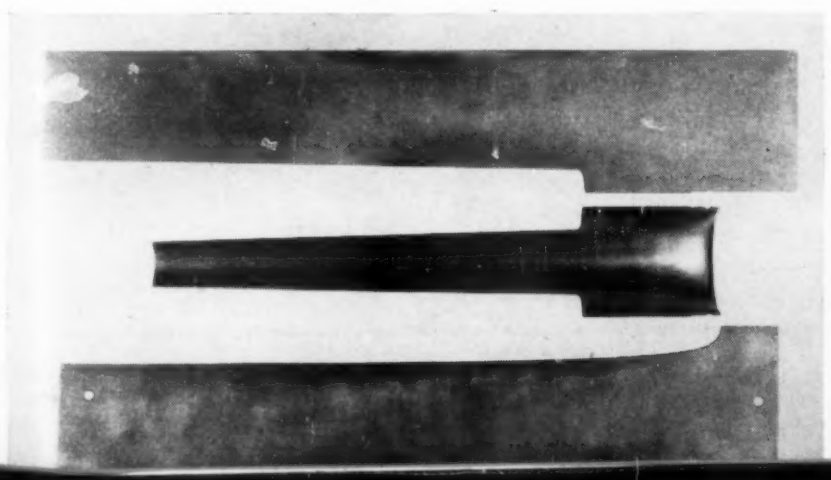


Fig. 1. The Ledoux bell and the contour templates, internal (bottom) and external (top) used for generating the parabolic metering surface and the steep step external contour.

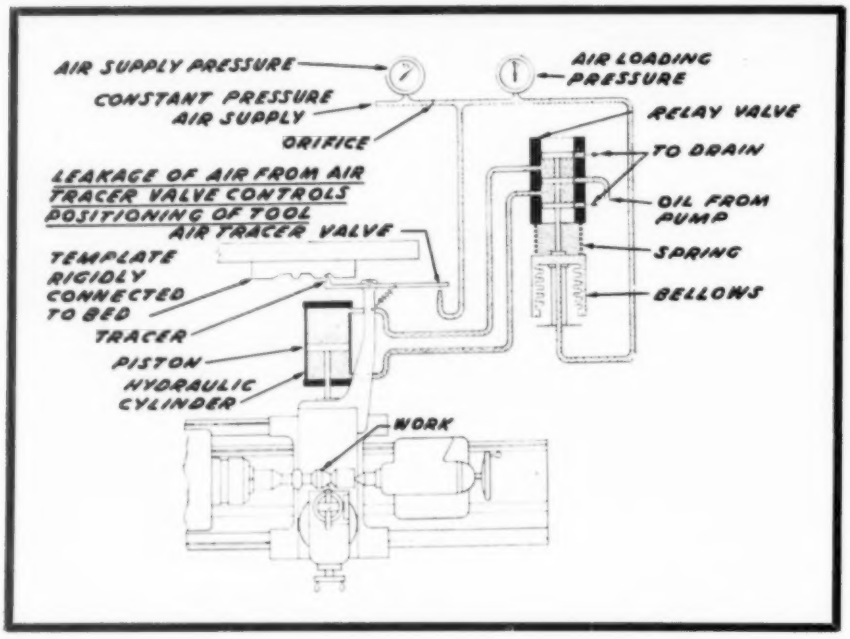


Fig. 2. The control, shown schematically, is essentially a balanced air loading pressure device arranged so that variations introduced by movements of the tracer are immediately compensated for in an air-hydraulic relay valve, the hydraulic element of which powers the movement of the tool slide. The movement of the tracer against the contour of the template introduces variations in air pressure; the relay valve functions automatically in restoring balanced air loading pressure.

of an air flow to create back pressure made minute measurements possible.

An experimental model of a control for lathe mounting that would combine the sensitivity of pneumatics and the smooth power of hydraulics was built.

Figure 2 is a diagrammatic sketch of the control.

Air–Hydraulic Circuit

The template is scanned by a spring-loaded air tracer. The slightest change in template contour increases or decreases the rate of flow from the air tracer valve. The amount of tracer movement from its balanced position is amplified into hydraulic relay valve motion. Air loading pressure is restored to balance as the tool slide moves in the direction and to the amount of the variation in the template contour.

While the first model was crude it proved so successful that the production department objected to the engineers taking it out of service long enough to run tests. Several other models were built as more jobs were turned over for them to do and skilled men were released for other work. In many cases the skilled men were replaced by women as the prewar production began to rise. The women operators, mostly housewives, were able to turn out more and far more consistent work than the skilled men who had operated the lathes without the air-hydraulic control.

The Bailey company was reluctant to enter the machine tool field. An improved design of the air-hydraulic control was built but the license to both build and market it in the machine tool field was granted to a leading machine tool manufacturer in 1946. This manufacturer has continued the development of the control and is supplying it as standard equipment on several lines of production machines. Incidentally, this manu-

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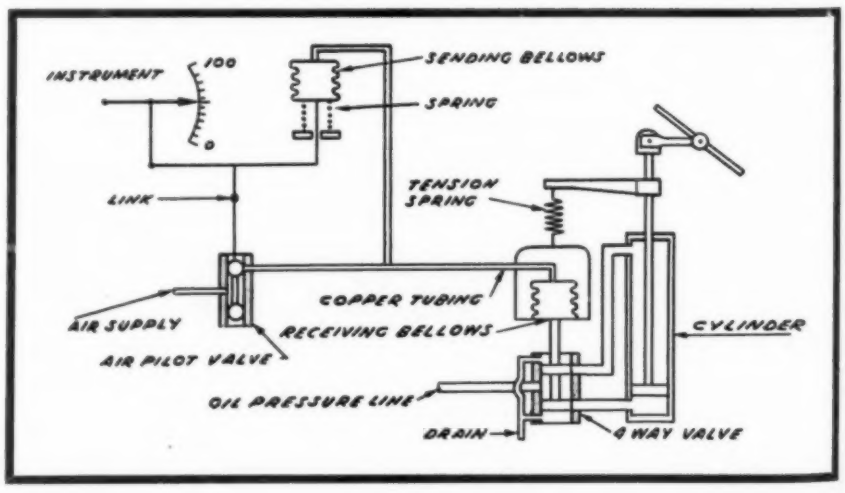


Fig. 3. Automatic control of air loading pressure by instrument for remote positive positioning. The arrangement is flexible—an air cylinder may be substituted for the oil cylinder when smoothness of control is not a requirement or where friction is not a problem. A hand operated air valve may be used where hand operation is desired.

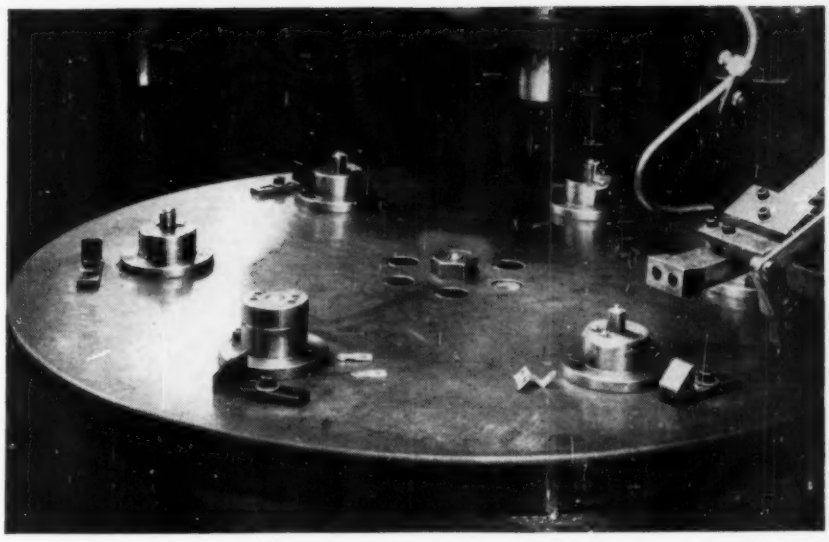
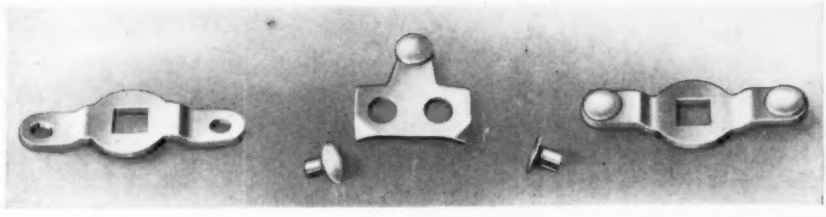


Fig. 1. The index table, chute base and an interchangeable adaptor is shown. The cam at each station actuates the automatic feed trip, allowing one contact to drop into position on the die. When two contacts are required the operator places the second in position manually. The air ejector is timed by a relay which is controlled by the ram action of the press. The table is shown indexing after the ram has completed an assembly.

Below are shown two of the assemblies; the same assembly, right, is complete, at the left is shown before assembly.



A VERY LIGHT TOUCH!

By
JOHN GILBERT
Methods Engineer
The Clark Controller Co.
Cleveland, Ohio

The cooperative efforts of two departments in the plant of a manufacturer of electrical control apparatus resulted in the choice of hydraulic equipment to gain accuracy and ease of control, greater production and to utilize the sensitivity of ram pressure for precision assembly operations.

IN THE ASSEMBLY of small silver contacts and bases we had the problem of finding a means of handling light and, at times, very small rivets and bridges fast enough to meet rather exacting production schedules. The high alloy silver rivets which are the contacts and the brass or bronze bridging members which are the bases were previously assembled in a kick press or in a punch press. This method was not only slow and expensive, but it also involved a monotonous, quite trying repetitive action by the operator which was fatiguing and, in practice, meant a decreasing production.

The Clark Controller Company makes electrical apparatus, much of which is for heavy duty industrial use. However, the assembly of elements does involve many operations in which small and light parts must be sub-assembled as in the case of the silver contacts and bases. Our problem was to find a convenient, automatic means of assembly that would not only be faster but that would lighten the fatigue load on the operator, since many of our smaller assembly machines are operated by women.

In attacking the problem our Methods Department worked very closely with our Tool and Die Department.

Assembly of Machine Elements

The Methods Department approached the problem from the standpoint of a high production technique. The job was to select and group a number of machine

elements. First, a bench size hydraulic press equipped with a hydraulically driven index table was selected. Then a hopper feed of a power screw driver was chosen to feed the silver contacts as required to the loading station. A second feed stop, which will be described later, was added and an air blast for ejection of the assembled parts and which would be operated by the upward movement of the press ram was provided.

The hydraulic press is a six ton standard model with reservoir and pumping unit totally enclosed. Piping is reduced to a tube between the relief valve and the control valve, one tube from the control valve to tank and one piece of tubing between the cylinder and the pressure gage. Other connections are of a subplate type. Electric motor, hydraulic pump and relief valve are mounted as a unit on a plate which also serves as a cover for the reservoir in the base of the press. Control valve and cylinder bolt together as a unit; the oil passages are internally cored in the castings.

Oil circuits are controlled automatically, although the press can be operated by dual safety control levers, which actuate a shipper rod connected to the control valve spool. Stop collars on this rod regulate the stroke length. The accurate pressure control required for our work is set by adjustment of the relief valve.

The hydraulically driven six-station index table is actuated by a fluid motor; the power is supplied from the press pump through a four-way control valve. The speed of indexing is adjustable well beyond the speeds we require for our assembly jobs.

The hopper feed of a power screw driver was included to provide a continuous, automatic supply of contact rivets to the loading station. We had a difficulty to overcome in feeding due to the fact that the regular stop in the feed chute was rather far up the chute. This was necessary because the feed track had to turn 180 degrees after passing this stop. This meant that the relatively light contacts would gain considerable momentum after passing the stop when released and that they would bounce off the die plate of the loading station.

Solution for Feeding Problem

This difficulty was solved by installing a second stop immediately in front of the automatic feed trip at the base of the chute. The first or stock feed stop was set with a clearance of .015 in and the second or base feed stop was set with a clearance of .004 in. The clearance was cut down so that the contacts would center accurately in position on the male die at the loading station. The operator then manually placed the bridge or base member over the contacts in position on the die as the station indexed past the front of the table.

The air blast was added to move the completed assemblies out of the die; we found an air action more positive than a mechanical ejector which would occasionally not clear the assemblies. An air ejector was also simplier than a mechanical ejector which would necessitate either cutting channels in the die or the use of cams for positive action.

The part played by the Tool and Die Department was essential to the successful production operation. The dies were very

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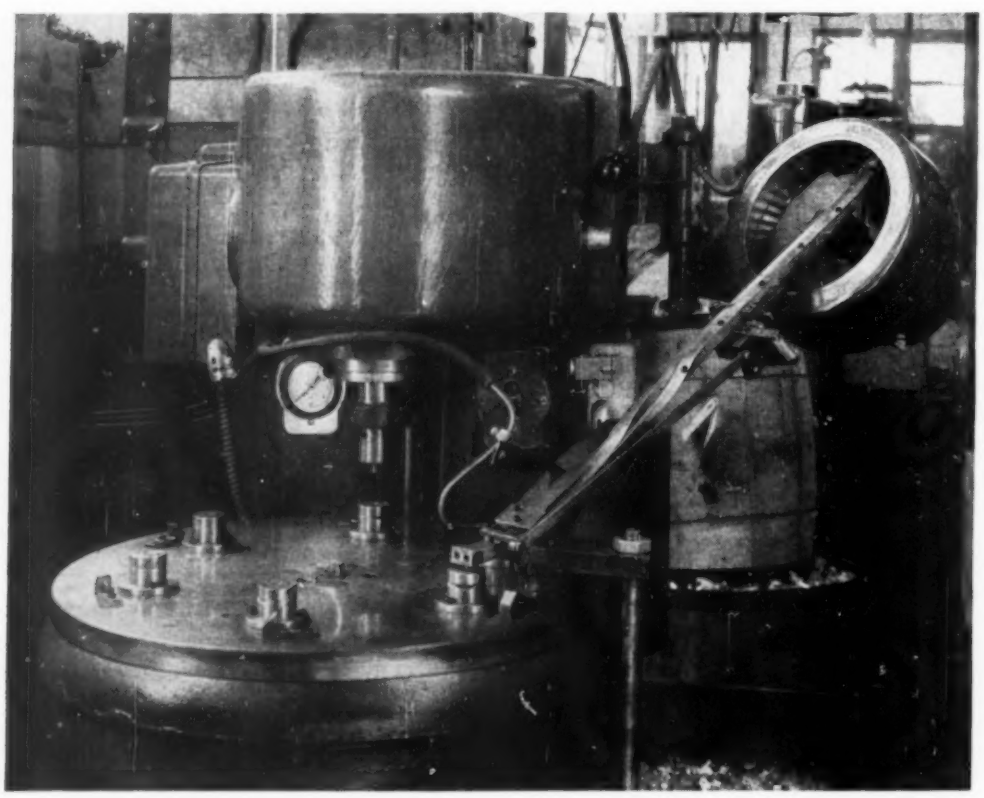


Fig. 2. The assembly of equipment includes a bench type hydraulic press equipped with an index table, specially equipped hopper feed of a power screw driver, an air ejector device and adaptors for quick interchangeability of similar dies.

(Continued from page 14)

equipment can be temporarily added as required.

After approximately one year of preparation, the program was incorporated into the classroom curricula of the 4-Year Machinist Apprentice Course. When the first group of apprentices finished this work, application cards were distributed to the employees of the Machine Repair and Tool Design Departments, offering the same course on an off-shift basis. Approximately 150 men enrolled. They met in groups of ten once each week for two hours over a period of ten months, either before or after a regular work shift. All necessary equipment was furnished by the Company. The combination of tool designers and repairmen proved to be mutually advantageous since each group was able to assist the other by pooling experience when attacking practical problems.

Outline of the Course

The hydraulic training course as set up was divided into five major units:

(1) Basic physics and hydraulics
(2) Pumps
(3) Valves
(4) Combination units
(5) Special circuits

Approximately twelve hours were devoted to study and demonstration of basic principles of physics and hydraulics; such fundamentals as conservation and transformation of energy, the relative incompressibility of liquids, Pascal's Law, work, power, horsepower and the flow of liquids being treated.

Pumps were investigated next, the students learning by demonstration and their own efforts how pumps are primed, the factors that effect volume delivery, efficiency and possible misfunction.

Valves were considered in the order of frequency of appearance in hydraulic circuits. Basic fundamentals appeared frequently in discussions of hydraulically balanced and pilot operated models. Each unit was studied from the cutaway model for design and functions; each was demonstrated on the table in operation, then finally applied to simple circuits for application.

Gradually, a combination of various elements was integrated into a unit designed for a specific purpose by the manufacturer. What had been a "mystery" or an intricate hydraulic device was now relatively simple as the function and operation of each component had been studied in sequence and each combination mastered in turn.

The special circuits, the last major unit in the training course, were readily understood and digested by the students' ability at this point to analyze each component. Hydraulics as applied to every type of machine in our plant, was still fascinating but no longer a mystery.

At the beginning of each session, students answered a set of review questions on the work of the previous session. Questions of the multiple choice type gave specific points on basic principles, valve operation or required pressure setting. Application and design questions gave students the opportunity to analyze circuits by graphically connecting components and by adding required equipment in order to produce a desired combination of movements or sequence of operations. Class discussion followed all review questions and these, including the correct circuits, were retained by the student for future reference.

Value of Training Program

The value of the hydraulics program has been demonstrated in a number of ways. Perhaps the most important result has been the growing practice on the part of the maintenance or repairmen to analyze the actions of improperly operating machines before applying a wrench. There has also been a sharp decline in the down-time of hydraulically operated machines. Another gain has been in the systematic preventive maintenance-routine checks to anticipate and head off trouble. There is no question that as the possibilities and limitations of the performance of hydraulic equipment are better understood, the result will be a greater degree of correct applications to tooling.

The results of our hydraulic training course have been in step with a slogan, popular in our shops, "you can't do today's work with yesterday's equipment and be in business tomorrow."

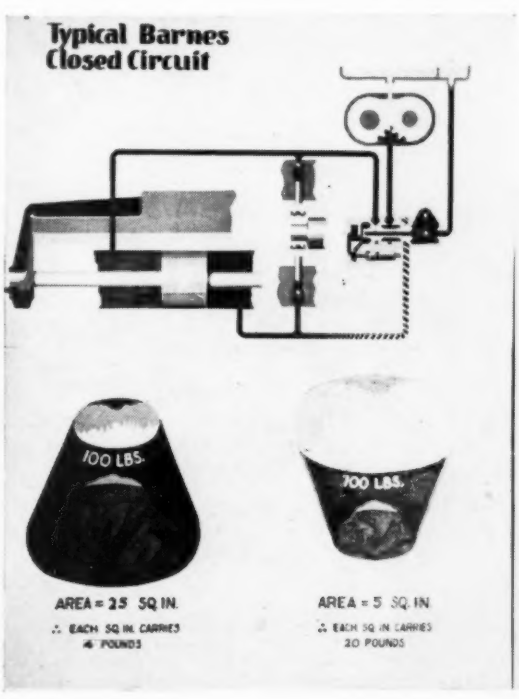
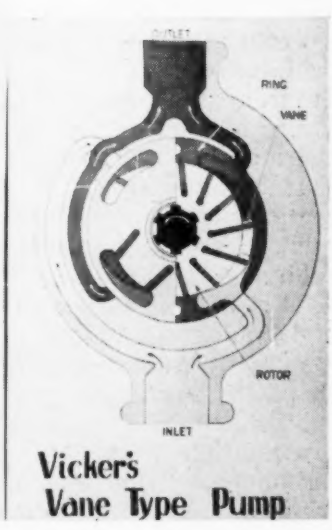


Fig. 4. Multi-colored charts are important training aids and assist in discussions of basic physics, equipment construction and special circuits.



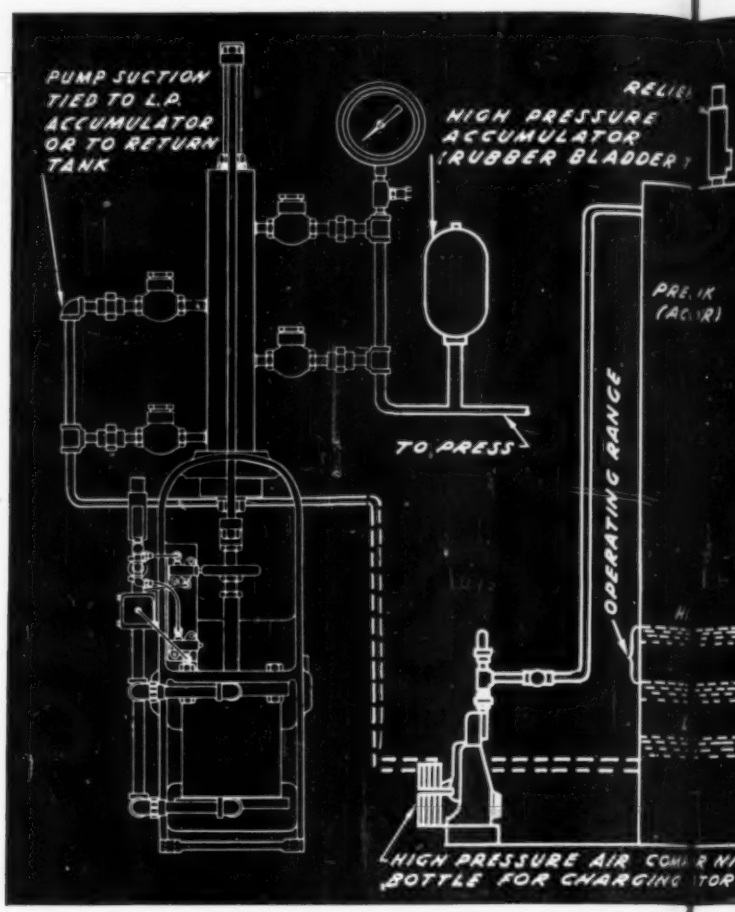

PUMP SUCTION TIED TO L.P. ACCUMULATOR OR TO RETURN TANK
HIGH PRESSURE ACCUMULATOR (RUBBER BLADDER)
TO PRESS
OPERATING RANGE
HIGH PRESSURE AIR

Fig. 1. Schematic of the central hydraulic system installed in a rubber molding plant.

REDUCING PRODUCTION COSTS IN B

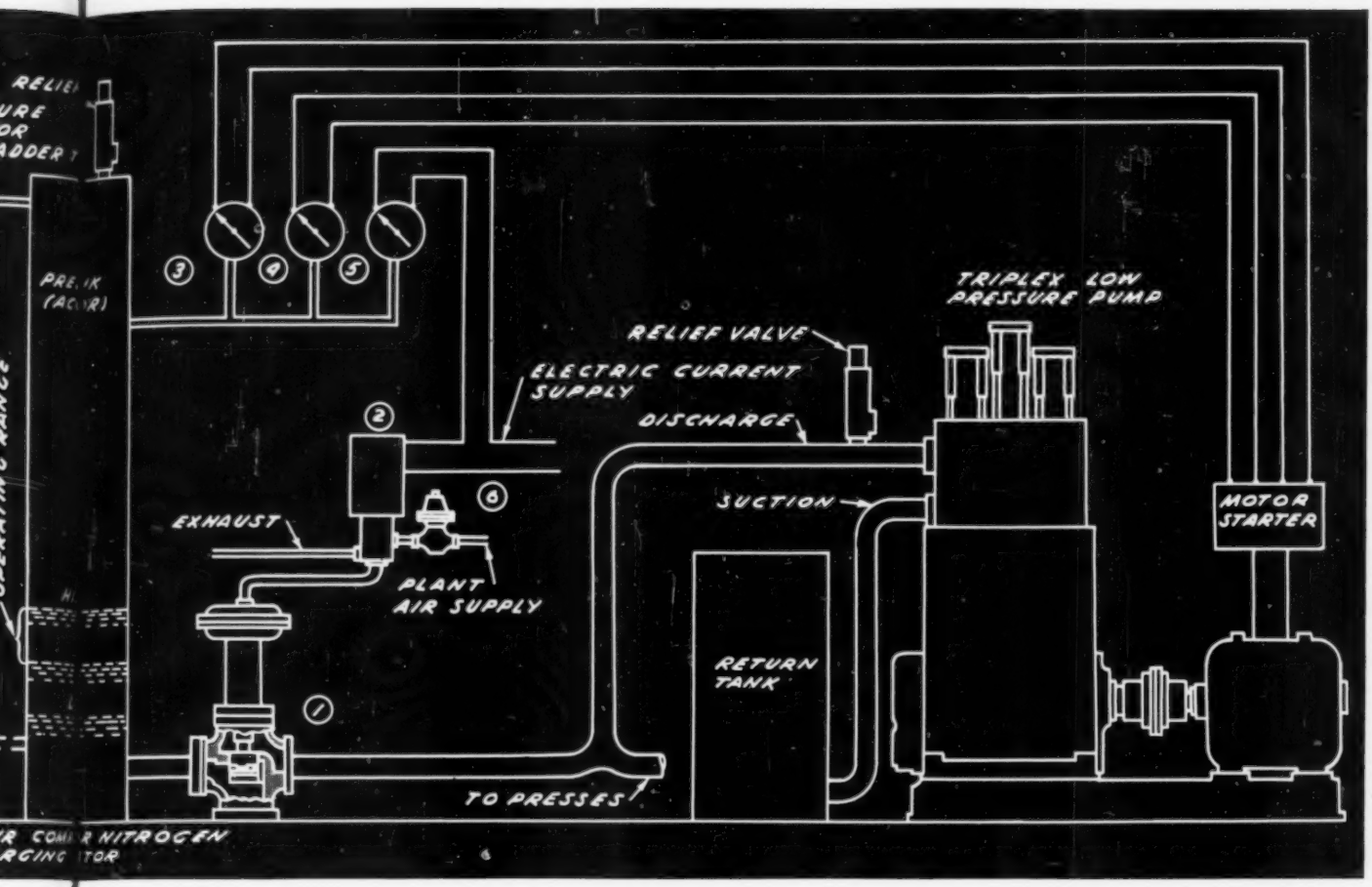
AT THE CLOSE of the recent war we were producing a limited quantity of molded rubber products on hand operated hydraulic presses. Before expanding our production facilities we made a study of available equipment and methods of plant operation to determine our chances of survival in active competition with the large and small manufacturers in our field.

This discussion deals with the high and low pressure central system which was worked out to power our entire group of rubber molding presses. At the present time we are operating fifteen presses on this system which is operated at peak power requirement on less than ten horsepower. Just how this is done will be discussed in some detail.

Essentially, the system is built around a hydropneumatic power unit—a double-acting, hydraulic pump which is operated by a vertical double-acting air cylinder and piston. This power unit or pump supplies a small amount of fluid at a desired high pressure by means of a small quantity of low pressure compressed air.

Low Pressure System—(300 psi)

As shown on the accompanying diagram and photographs, the pumping unit for this system is of the vertical triplex type driven by a 5 hp motor. The pump is used in combination with a tank type accumulator which stores the hydraulic medium delivered by the pump during periods of low demand and delivers this medium to the hydraulic press line during the periods when the demand exceeds the pump capacity. The upper two-thirds of this accumulator contains an air or nitrogen charge which is in direct contact with the liquid. Accordingly, it is necessary to add to the charge from time to time to make up for its absorption in the liquid. This is accomplished without shutting down our system and we feel that this disadvantage of charge absorption



N BBER MOLDING

By WILBUR TAYLOR
President
Taylor Bros. Co.

The use of a high pressure hydraulic pump operated by plant air pressure to provide clamping pressure on rubber molding presses which are closed on low pressure. The simplicity of both high and low pressure sides of the system, ease of control and low maintenance combine to establish this type of system as an important factor in efficient plant operation.

is minor by comparison with the maintenance involved in the use of piston or weighted type accumulators.

The three pressure switches shown on the diagram (3, 4 and 5), control the operation of this system. Two switches are used to stop and start the pump motor over a 50 psi pressure variation. The main pressure switch (3) is the motor control switch. It stops the motor when the pressure in the tank reaches maximum operating pressure (high level) and starts the motor when the pressure drops to low operating pressure. The second switch (4) is a mercury type pressure switch and is set approximately 10 percent higher than the main pressure switch; in the event of failure of the main pressure switch, switch 4 cuts out the pump motor to prevent overload. The third switch (5) closes a diaphragm operated valve which isolates the accumulator from the press line in the event that the air or nitrogen charge in the tank drops to a predetermined point (indicating an excessive loss of fluid somewhere in the line) preventing loss of the accumulator charge. When the pressure builds up in the system, the third switch makes contact and loads the diaphragm valve (1) with air, holding it open.

High Pressure System

Our high pressure system is unique and, as far as the writer knows, is the first system of its type ever installed. For this reason, we will go into more detail in explaining its method of operation. Our high pressure fluid is supplied by a double acting hydraulic pump driven by a double-acting air cylinder. In our case the fluid used is water.

However, oil could be used in exactly the same way. We add a 3 percent water soluble oil to our water.

The construction of this pump is extremely simple. It consists of two hydraulic plungers operating in separate chambers in a fluid end with both plungers yoked to an air cylinder. In this fluid end, four ordinary high pressure check valves are used as intake and discharge valves.

Some designers may object to air as expensive. However, let us examine the power cost as compared to a motor driven pump. The ordinary hydraulic pump powered by an electric motor is commonly controlled by one of three methods:

1. By stopping and starting the driving motor through a pressure control.
   This method of control results in excessive power consumption due to the high starting voltages required; also the pressure in the hydraulic line must drop to a definite pressure before the control restarts the pump.
2. By by-passing the hydraulic medium around to the pump intake when it reaches working pressure. This is always a source of power loss since the pump is being driven at capacity while the pressure is being dissipated. Furthermore, undesirable heating up of the fluid may result.
3. By employing some type of unloading device which unloads the pump when operating pressure has been reached. Such an action reduces the brake horsepower until such time as the line pressure has dropped low enough to cause the unloading device to again load the pump.
   An unloading device is an expensive, delicately balanced mechanism which usually operates on a pressure differential principle, resulting in a lag between pressure drop and the pump loading.

Fig. 2. The low pressure system with accumulator, diaphragm operated valve, solenoid, air filter, air reducing valve, main pressure switch and two mercury pressure switches. The air compressor with 5 hp motor is installed below in the boiler room.

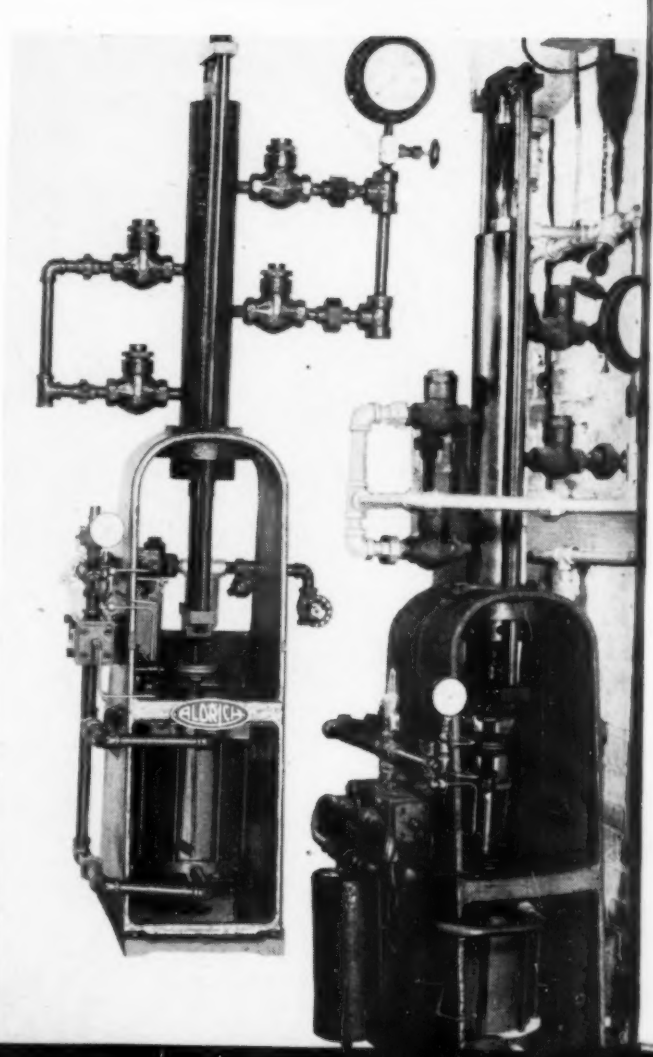


Fig. 3. The air driven high pressure pumping equipment. Front and side views are shown.

Rather than go into the disadvantages of the methods outlined, we will confine ourselves to a brief discussion of the advantages of the air driven unit.

Design of Pump or Booster

This pump, booster, or whatever you may choose to call it, is designed so that the ratio between the air cylinder and the plunger diameters is such as to deliver the required hydraulic pressure, utilizing the available shop air pressure as a driving medium. Obviously, increasing or decreasing the air pressure will directly control the pump discharge pressure. By using an air pressure reducing valve at the air cylinder intake, it is possible to control the inlet air pressure and so control the pump discharge pressure over a wide range. This makes it possible to vary the discharge pressure by means of a simple air reducing valve adjustment.

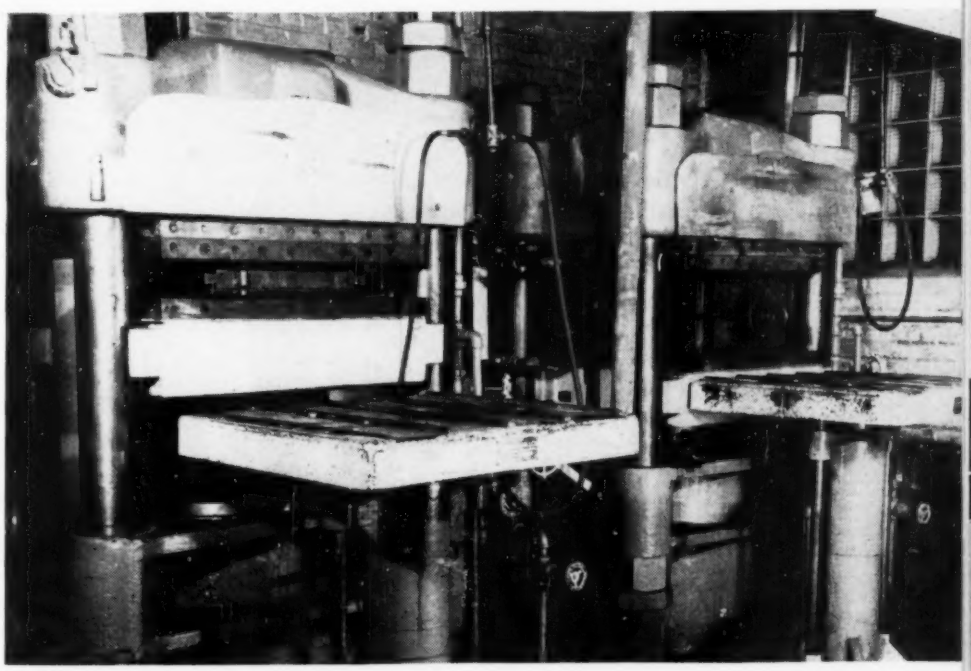
This unit in operation rides the line in the same manner as a steam pump. It stalls when operating pressure is reached and strokes up and down at whatever rate of speed is required to meet the hydraulic demand from the system. This rate of speed is surprisingly low since our 300 psi low pressure system is adequate to close our presses and only a small volume of high pressure water is required to provide clamping pressure on the molds. A cup of water removed from a barrel of water at 3000 psi drops the pressure to zero; while that same cupful forced back into the barrel restores the original pressure. The low air consumption of the air driven pump is proof of the fact that very little water needs to be displaced to boost pressure from closing pressure to clamping pressure.

The total amount of compressed air used for driving the pump is furnished by a small portable, air-cooled, tank mounted, air compressor driven by a five horsepower motor. The air from this compressor is also used to blow out our dies, for operating a small sand blast machine and for various other small jobs around the plant involving the use of air. We are operating fifteen presses with a maximum of ten horsepower for the combined high and low pressure systems. We believe that we could add at least five more presses to our line without adding to our pumping equipment or materially affecting the efficiency of our operation.

Since the air pressure directly determines the hydraulic pressure, we are able to eliminate the use of high pressure hydraulic relief valves and substitute air pressure relief valves on the air end of the pump to prevent any build up in excessive pressure.

The high pressure accumulator shown in Fig. 3 consists of a rubber bladder inside of a steel

Fig. 4. These rubber molding presses, each with 22 in ram and 18 in stroke are part of the equipment operated by air power in the Taylor Bros. plant.



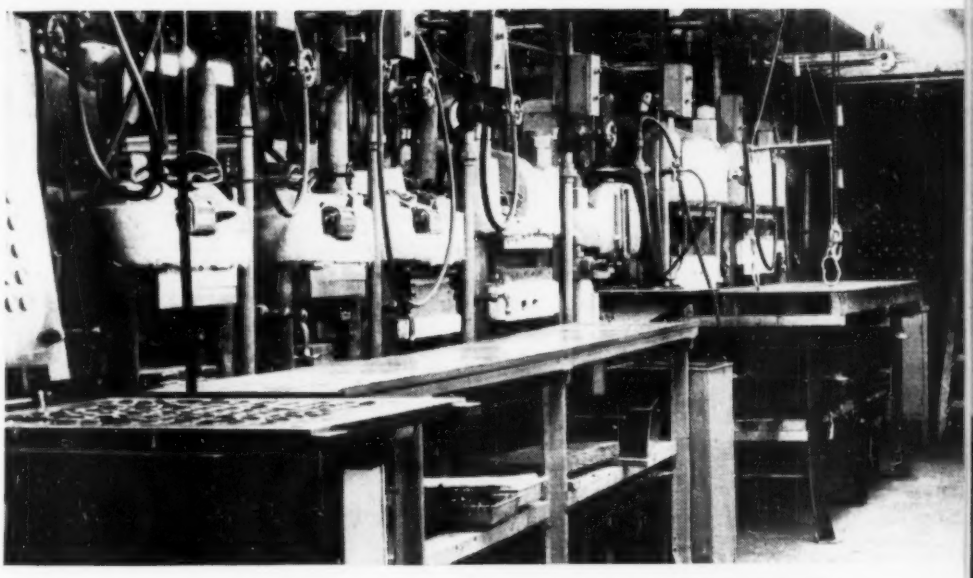


Fig. 5. A section of the hydraulic press line in the Taylor Bros. plant.

shell. The bladder is precharged with air or nitrogen at a pressure of two or three hundred pounds below normal operating pressure. The chief function of the accumulator is to eliminate momentary pressure drops which may occur on the pump stroke reversals, and to insure uniform, slow travel of the pump plungers.

Two Air Pumps

Two air driven pumps are shown in Fig. 3. The first unit, at the left, was installed over two years ago. The second unit was installed as a standby unit about a year ago. Either unit can carry the entire load. As far as we can determine, the first unit is operating as efficiently as it did when first installed. Maintenance has been practically negligible and has been limited to packing replacements (approximately every nine months) and the removal of scale from check valve seats on one or two occasions. Since plungers are outside packed, the average packing replacement job can be done in approximately 20 minutes.

In all fairness, the writer would like to point out that the proper functioning of the pump, as outlined above, is dependent upon other factors outside the pump itself. It is based on a reasonable amount of maintenance in our hydraulic lines, hydraulic valves and in the presses.

Any undue losses in line pressures caused by faulty valves, leaky press packings, etc., are immediately reflected by an increased speed in pump plunger travel. Actually, such an increase in plunger travel is an accurate check on the efficiency of operation of our system. This enables us to run down and locate sources of power loss in the system which otherwise might remain undetected for days or even weeks.

We have been able to expand our production and keep our maintenance cost at the lowest possible point; this has enabled us to meet postwar competition in our field on a favorable basis. We feel that our air power equipment has played a very definite part in our ability to secure and keep a very reasonable share of rubber molding business.

CONTROL OF HYDRAULIC ELEMENTS BY AIR

(Continued from page 16)

facturer, in turn, has licensed several other non-competing machine tool manufacturers for application of the control on their machines.

The second application, the air loaded principle for remote positioning control is in reality a very old control principle. It is used, with variations, by a number of instrument control manufacturers. Its flexibility has been an invitation for machine designers and production engineers to incorporate such a control which can be automatic or hand controlled, an all air system or air loaded and hydraulic actuation for the positive positioning.

Figure 3 is a diagrammatic sketch of an air loaded, hydraulically powered arrangement for remote mechanical control by positive positioning.

Remote Positioning Control

It is essential that air at a constant pressure be supplied to the system. Various manufacturers have designed their equipment for specific constant pressures. These pressures are maintained by pressure reducing valves. Figure 3 shows the air pilot valve in a balanced position, the system has responded to the instrument setting and both the sending bellows and spring and the receiving bellows and tension spring, as well as the four-way valve in the oil circuit are in equilibrium or neutral position.

When the instrument calls for more air pressure, the instrument side of the differential linkage moves up, raising the pilot valve out of neutral, causing more air to flow into the loading line. This action expands the sending bellows and compresses its spring, lowering the right hand side of the differential linkage and restoring the pilot valve to equilibrium. This bottles up the new pressure in the loading line. This increased pressure expands the receiving bellows, extending the tension receiving spring and moves the spool of the four-way valve to open the top port to drain and open the bottom port to pressure. This permits an oil flow into the cylinder behind the piston, causing the piston to move upward until the tension spring balances the new load in the receiving bellows and restores the four-way valve to neutral position. By this action the mechanical linkage moves the machine part to be controlled, shown here as a damper, to the setting called for by the instrument.

Friction in Air System

To function accurately the air system must operate without friction. The entire system up to and including the four-way valve must operate without friction. Furthermore, the oil valve must be of a design that is inherently stable. If there is friction in the system or the oil valve design is not stable, the system will be unstable. Friction beyond the four-way valve does not affect the operation of the system.

An air cylinder may be substituted for the oil cylinder to make the entire remote control system air operated. This is practical and may be preferable when smoothness of control is not essential or where friction is not a problem.

A simple hand operated air valve may be used to set up the loading pressure instead of the control by instrument.

This type of air loaded remote control is a very old yet not widely used nor understood except in the instrument field. There are many applications for it on industrial equipment which is operated automatically and where remote control is advantageous.

vents or air bleeders at the places in the system where air tends to

SAVE THIS VALUABLE REFERENCE MATERIAL. BUILD UP A PERMANENT FILE

*APPLIED HYDRAULICS, February 1948, pp 35-36.

IRREGULAR OR JUMPY FEED

By EARNEST Y. SEBORG
Hydraulic Engineer
Barnes Drill Co.

THIS ARTICLE deals with one of the most frequent troubles encountered in hydraulic systems, namely, irregular or jumpy feed. Feed is that part of the stroke on a machine tool in which the cutting tools do work. Because nearly every hydraulic man has encountered this condition at some time or other and because some have had more experience than he, the author realizes that his neck is way out and welcomes comments and criticism.

Jumpy feed is due to the compression and expansion of the hydraulic fluid or the expansion and contraction of its container, namely the cylinder and piping. If the motive power is a hydraulic motor, the container to be considered would be just the piping.

If hydraulic cylinders are designed with proper cylinder wall thickness and if recommended piping and tubing are used for the working pressure of the system, the expansion and contraction of the container is not an important factor.

Air in System

One of the most common causes of irregular feed is air in the system. This air compresses and expands with variation of load, thus causing the jumpy feed. Hydraulic machine designers usually make arrangements to free the system of air. This is done in several ways. A good rule to follow is to have all cylinder ports wherever possible come out of the top side of the cylinder. If the cylinder is horizontal, ports should come out of the top of the periphery. If vertical, one port should come out the top end and of course, the others cannot. The air accumulates at the top side of the cylinders when the machine is at rest. With the ports at the top, the oil when circulated will automatically carry off the accumulated air, since it is not trapped as it would be with the ports part way down on the cylinder.

In some cases it is not possible to have the ports on the top of cylinders or the circulation of oil back and forth through the cylinders is not sufficient to carry off the air. In these cases, it is necessary to put vents or air bleeders at the places in the system where air tends to accumulate. Caution should be used in the use of air vents because unless the seat of the vent is tight, it can be a point of entry for air into the system. These vents should be opened only when there is pressure at that part of the system. This is particularly true in systems where the cylinder is above the oil level of the hydraulic tank. In such systems where the cylinder is a number of feet above the tank oil level, the head of oil will tend to suck air through the cylinder packings, vents and fitting connections when the machine is idle. An air vent in such a system, if not tight, can let air into the system without showing an oil leak. Sometimes a back pressure valve is placed on the discharge lines to overcome the static head of oil.

In some systems a common line is used as a discharge for two or more different cylinders that operate at different times. In these systems a venturi effect is sometimes set up across the tee when one cylinder is operating and tends to suck the oil from the other cylinder line. If this line and all packings connected to it are not tight, air will enter to take the place of the oil that is sucked out.

In a previous article,* the author mentioned that a good hydraulic oil should be used in the hydraulic system. One of the properties of a good hydraulic oil is that it should have a good demulsibility number. Demulsibility indicates the ability of an oil to resist mixing with water. It is known that air will mix more easily with an oil with a poor demulsibility number and that such an oil will not readily free itself of this air. It is therefore necessary to have a good hydraulic oil to have air free operation.

Compression of Oil

As the compression and expansion of the air in the system causes irregular feed, the compression and expansion of the oil itself can cause a jumpy feed under certain conditions of operation. Many people think of liquids as being non compressible. This idea is wrong. It is true that liquids do not compress like gases, but the compression of oils is enough

*APPLIED HYDRAULICS, February 1948, pp 35-36.

to cause trouble on certain machines. A six foot long column of hydraulic oil of 150 SSU at 100 F will compress approximately ¼ inch under 1000 psi pressure. This compression is approximately in direct proportion to pressure up to 2000 psi.

Suppose a machine has a jumpy feed which develops whenever the feed rate is adjusted to a very slow rate, say anything below 1 inch per minute. This jump develops when the machine is operating without doing work. The air has all been bled from the system and the oil in the tank is free from air bubbles. It must also be assumed that the hydraulic system has been properly designed and meets the minimum volume requirements of the feed pump or metering valve manufacturer. Then this irregular feed is the result of compression and expansion of the hydraulic oil caused by an irregular friction load. The machine should first be checked for some unnatural friction load such as clamps or gibs being too tight on the traveling head ways. The cylinder might be out of line with the traveling head so that it tends to bind the piston rod. The packing on the rod itself might be too tight or the piston rings might have been fitted with too little clearance. If all these things are checked and the jumpy feed continues to take place, it is probably due to the natural difference between static and moving friction. This is more apt to be true if the moving machine part is heavy and moves on a horizontal plane. When the rate of feed is below one inch per minute, the coefficient of friction tends to vary between the coefficient of static and moving friction. If the machine part weighs 10,000 lbs and the static coefficient of friction is .3 and the moving coefficient is .15, it will require 3,000 lbs to start the motion and 1,500 lbs to keep motion going at a reasonable rate. With a 6 in diameter cylinder, having an area of 28.3 sq in, the pressure required to overcome static friction is 3,000/28.3 or 106 psi. The pressure required to overcome moving friction is 53 psi. This means that when traveling at 1 inch per minute or less, the pressure must build up to 106 lbs and the oil in the cylinder is compressed. Then, when the head begins to move, the pressure required drops to 53 lbs. The tendency is for the oil to expand and move the head faster than the metering valve or feed pump can furnish it to the system. As a result, the head jumps forward rapidly, then waits for the oil to again be compressed to the 106 lbs. If the column of oil behind the piston is 4 feet long, an anticipated jump of about

$$\frac{4\text{ ft}}{6\text{ ft}} \times \frac{106\text{ psi} - 53\text{ psi}}{1000\text{ psi}} \times \tfrac{1}{4}\text{ in compression of 6 ft column at 1000 psi} =$$

.009 of an inch could be expected from the friction caused by weight. The friction of the piston rod, gibs and clamps as well as the inability of metering or pressure valves to function properly under these conditions tend to multiply this jump.

In order to correct a jumpy feed under these conditions, it is necessary to make the static coefficient of friction approach the value of the moving coefficient of friction. This can sometimes be done by cutting down on way contact area and by providing a pressure lubrication system so that the machine part actually rides on a complete oil film. At other times a change in way lubricant may give the desired smooth feed. A larger cylinder, of course, will tend to cut the difference in pressure and will reduce compression.

Tests have shown that changing the hydraulic system from metering in either by metering valve or feed pump to metering out will have little effect on jumpy feed caused by compression and expansion of oil due to friction in the machine.

Chatter

Sometimes a chatter is set up in a machine tool when the cutter contacts the work. This might be caused by the cutter tending to pull itself into the work at a rate greater than the feed rate, thus making the feed irregular. If this tendency is not too great, it can be corrected by setting up the back pressure on the feed cylinder. In some cases, it might be necessary to change the angle of the cutters.

During facing operations on machine tools, a chatter is often set up as the facing tool cuts itself clear when the head contacts the positive stop. This is often caused by the stop tending to spring under the hydraulic force as it is transferred from the work to the stop. The best correction for this is to build the stop so that it cannot spring.

Applied HYDRAULICS DIGEST

Abstracts, summaries and listing of articles on hydraulic and associated applications in industry; reports on prepared papers, talks and discussions of special interest to the hydraulics field.

Special Machinery Output Accelerating

Howard C. Tuttle, *Steel,* v 122, January 26, 1948, pp 32, 33, 119, 120.

A survey of the remarkable increase in the building of special machinery—more than 1000 percent greater than in the immediate prewar period. This record was made in the face of shortages in steel, motors and other electrical equipment, bearings and ferrous castings.

In woodworking equipment, including equipment for home craftsmen, the year saw a record production which promises to continue through 1948. Food processing and packaging machinery was produced during 1947 at five times prewar volume despite shortages of components and labor difficulties. A major machine builder, Allis-Chalmers Mfg. Co., Milwaukee, in the pulp and paper mill machinery field, reported its 1947 sales as 40 percent above 1946 which had been 10 times greater than the average of the four years immediately prewar. Another, Samuel M. Langston Co., Camden, N. J., reports a backlog of two years, at a rate 50 percent higher than 1946.

Machinery for the graphic arts industry is now being produced at twice the prewar rate but production still lags far behind demand. Partly due to a long reconversion—the author says about 20 months—unusually long manufacturing cycles, in some complex machines as long as nine months, as well as labor and material shortages, partial relief from the printing machinery famine is only now beginning to be felt.

Machinery production for the petroleum industry was 50 percent greater than prewar and 10 percent above 1946 production and approximately equal to the demand. A slight easing in demand is expected in 1948. However, a major producer of a wide range of equipment used by oil refineries—Worthington Pump & Machinery Corp.—estimates its 1947 output at two and a half times its prewar volume and 25 percent greater than 1946.

The National Association of Textile Machinery Manufacturers reports the 1947 volume at about 50 percent greater than prewar, but that due to the export demand, some member companies have produced far above this average. With the present heavy backlog, the builders anticipate the high production rate to continue for an indefinite period.

Hydraulic Clutch

Warren E. Wilson, *Machine Design,* v 20, January 1948, pp 115-119.

An analysis of the mechanics of operation of a positive-displacement type hydraulic clutch. An idealized setup is used as an example and the performance is described mathematically. Three types of load acceleration are illustrated by examples and the operational characteristics of the clutch are discussed in detail. A calculated performance with the clutch connecting a drive shaft to a purely inertial load is worked out.

To obtain smooth operation which has been suggested as a definite possibility, the orifice area must be controlled. Diagrams show the ideal relationship between variable-orifice area and time for smooth clutch engagements; pressure within the clutch during engagement and speed-time relationship during clutch engagement.

The author concludes that the possibilities of suitable performance characteristics are governed by orifice area and rate and manner of closure but that further analysis is in order to more completely establish the criteria for good clutch performance.

Compressed Air—The Great Equalizer

Vaners Borg, *Tool Engineer,* v 19, January 1948, pp 43-44.

The application of compressed air to many operations in a small tool shop—Accurate Tool & Engineering Co. of San Diego, Calif., gave advantages ordinarily possible only in large manufacturing plants.

One application of an air cylinder on a contract job was to force a top roll against two bottom rolls in a stainless steel strip rolling operation. Any other power available would have involved much greater cost. Two other applications on the formed rings were also air powered. The rings are held to the electrodes in a flash welding machine by compressed air; after which an air cylinder, solenoid controlled, is used to clamp the rings for a trimming operation.

Still another application was on a tool grinder with a hand operated table. An air motor con-

verted the table to power travel, reducing operator fatigue and increasing production.

Two 5 hp two-stage air conpressors, one ordinarily acting as a standby, provide 100 psi air for this "air minded" tool shop.

How to Control Maintenance Costs

G. W. Norris, *Air Transport,* January 1948, pp. 33-35.

A description of a graphic technique for preventive and remedial maintenance in which a centrally located maintenance chart room is utilized. Various procedures are given in labor hours, the charts being used as a cost control. The technique described merits study by industrial hydraulic maintenance engineers in large or in medium sized plants where maintenance procedures have not been accurately cost controlled.

Compressed Air Used as Major Power Source

Anon., *Steel,* v 122, January 19, 1948, pp 80, 82.

Compressed air is used as a major source of production power in the Passaic, N. J. plant of Robins Conveyors, division of Hewitt-Robbins, Inc. Air equipment in three departments are especially noteworthy. These are the foundry, the core department and the fabricating and erecting shop. In the foundry molding machines use air for such operations as vibrating and compressing sand in the molds, shaking loose plates that compress the sand and removing remaining sand particles from the machine before they receive the patterns. Some of these machines are arranged to upend the mold by means of compressed air; portable tampers are used to pack sand in some molds.

In the core department compressed air is employed in the operation of a core blowing machine; the sand is fed automatically into a form and air pressure forces it into each detail of contour, thus producing a superior molding core. After the casting has been removed from the mold and cleaned, the core sand that remains in the hollow centers of roller castings is removed by portable air drills.

In the fabricating and erecting shop, stock to be cut in the power shears is clamped by means of compressed air; on welded parts excess metal from the welding operation is removed by use of portable air grinders. Air grinders are also used for finishing a number of metal surfaces that are to be fitted to other parts. In the riveting assembly of large machines, such as mechanical sorting screens, air hammers and air driven portable nut drivers are employed.

Finished parts of conveyor equipment are painted by an air powered spray gun; conveyor roller bearings are pressure greased by air pressure. Three motor-driven air compressors provide air at 100 psi; two machines are 15 x 9 x 10 in and the other a 8 x 9 in machine.

What to Look for in Hydraulic Oils

(Continued from February issue)

Anthony F. Zino, Jr., *American Machinist,* v 92, January 1, 1948, pp 96-99.

Part V, "Oxidation Stability" is defined and the basic crudes are listed. Optimum temperature range is stated as 110-130 F. The effects of polymerization and thermal decomposition are discussed. Three causes of contaminants, particularly cutting oils, pipe threading compounds, rust-preventive compounds, greases, core sand and dirt are given with suggestions for their elimination. The importance of the selection of the least reactive metals to reduce the catalytic effect of metals, is stressed. The ASTM "Proposed Method of Test for Oxidation Characteristics of Steam-Turbine Oils" is recommended for evaluating oxidation stability of hydraulic oils.

Ibid., January 15, 1948, pp 97-100.

Part VI, "Lubricating Value". Three characteristics that affect the lubricating value of an oil are discussed: (1) oiliness; (2) extreme pressure or anti-weld properties; and (3) composition of the rubbing surfaces. The characteristics are defined, the parts they play in hydraulics and the present methods for evaluation are given. The ultimate load-carrying capacity or wear-resisting characteristic of an oil's film is discussed and a check list of the points at which oil film is most likely to break down is included. The value of superfinished surfaces is shown by a wear chart.

Ibid., February 12, 1948, pp 126-128.

Part VII, "Non-Corrosive Qualities". The causes and effects of rust and of corrosion are set forth and the action of rust inhibitors is discussed. Two tests—ASTM Test D665-46T for evaluating the rust-preventing characteristics of steam-turbine oils in the presence of water and the Humidity Cabinet Test are described. Corrosion resistance is directly influenced by resistance to oxidation (see Part V) and is improved by processing oil with oxidation inhibitors. The damage caused by rust and by corrosion is listed separately in a box. In this article, like in others in the series, photographs of typical failures of pump and valve parts due to oil changes and contaminants are well chosen.

Hydraulic-Electric System

Walter E. Bock, *Machine Design,* v 19, December 1947, pp 107-111.

A description of the Automatic Magnaflux inspection machine which utilizes the magnetic-particle method for disclosing discontinuities by manual inspection. The machine was designed for the inspection of crankshafts and camshafts. The conveyor, which operated intermittently, since it had to provide periods of rest

for the successive loading, magnetizing, inspection, demagnetization and rinse-unloading stations, is hydraulically powered by a drive cylinder which advances the conveyor one station by its forward movement.

Two sets of lifting and clamping cylinders are used to swing the circular or contact heads into position for particle spraying and the clamping cylinders, by moving forward, securely hold the parts. A duplicate set of control valves are provided. The drive cylinder operation is controlled through valves in the same system. The speed of outward and return strokes of the drive cylinder piston are easily adjusted to the timing cycle of operation of the machine. This eliminated the need of a manual change of gears or of a variable-speed mechanism, clutch or brake for proper timing.

Complications were encountered in adapting the machine for circular or longitudinal magnetization which could have been solved by the addition of duplicate electrical equipment. This was discarded as excessive in cost and undesirable because of the space it would occupy. The final answer determined upon was the addition of two limit switches, two relays, two pneumatic timers and two large magnetic contactors. A safety limit switch, at the unloading station, automatically stops the hydraulic pump motor, if the part at that station is not removed before the conveyor advance begins.

All controls are interrelated so that the steps in the operating cycle are definite and fixed. The failure of any step stops the entire machine. An electric "brain" in the control circuit automatically picks up the cycle after a stoppage.

Dial Feeds Synchronized by Air

Joseph F. Budnick, *American Machinist,* v 91, November 6, 1947, pp 101-103.

Indexing by means of a reciprocating action of a gib-restrained slide which is moved through a cushioned spring by the ram of a double-acting air cylinder is described and diagrammed. Various applications to control chute, tubular hopper and vertical feeds are outlined and illustrated.

Obtaining Attenuation — Frequency Characteristics for Servo-Mechanisms

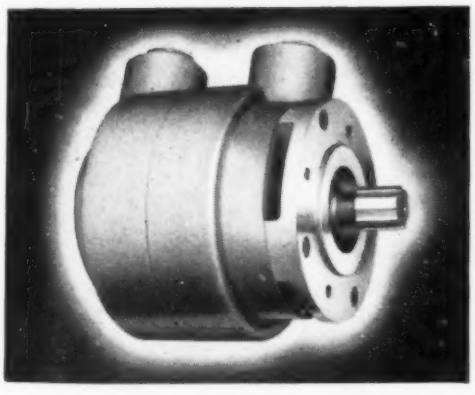
H. Chestnut, *G. E. Review,* December 1947, pp 38-44.

A series of charts and sketches of attenuation diagrams described in this article permit the selection of an appropriate type of R-C network to obtain a number of the more useful attenuation-frequency characteristics. A large number of networks are presented so as to indicate how control may be obtained of various portions of the attenuation-frequency spectrum by the presence or absence of series and shunt elements.

(Continued on page 40)

Built To Be The Greatest Value In The Field!

The New DUDCO Vane-Type SMALL PUMP Now Costs Only $150 ***(Pressures Up to 3000 psi)***



Here's an outstanding small series hydraulic oil pump ideal for applications requiring an economically priced high pressure pump, where competition hasn't allowed the use of higher priced 2000 psi pumps. Volumetric efficiency 97%. Overall length 8". Diameter 6½". Weight 60 lbs. Delivers 2 to 18 gpm at 1200 OR 1800 rpm. A revolutionary Dudco patented feature balances the radial vanes hydraulically for both pressure and flow, and eliminates bearing loads. These pumps are available in *completely packaged power units,* including relief valves, motor coupling, electric motor, filter, pressure gauge, outlet and return lines. Delivery within 3 to 4 weeks.

DUDCO SMALL SERIES PUMP
(2000 PSI)

Model No.	Del. GPM @ 1800 RPM*	Maximum Pressure PSI	Peak Pressure PSI	HP Input @ Max. Pressure
P-2	2	2750	3000	3.8
P-3.5	3.5	2750	3000	6.6
P-5	5	2500	2750	8.6
P-8	8	2250	2500	12.4
P-15	15	2000	2250	20.6
P-18	18	1750	2000	21.6

*Pump for volume shown also available for 1200 RPM operation

Also Larger Series DUDCO VANE-TYPE PUMPS

The P-32 series for 2000 psi up to 32 gpm, and P-60 for 750 to 1500 psi up to 80 gpm. Dudco small or large pumps can be used in combination for high volume low pressure and low volume high pressure requirements. (Also two series DUDCO MOTORS available.

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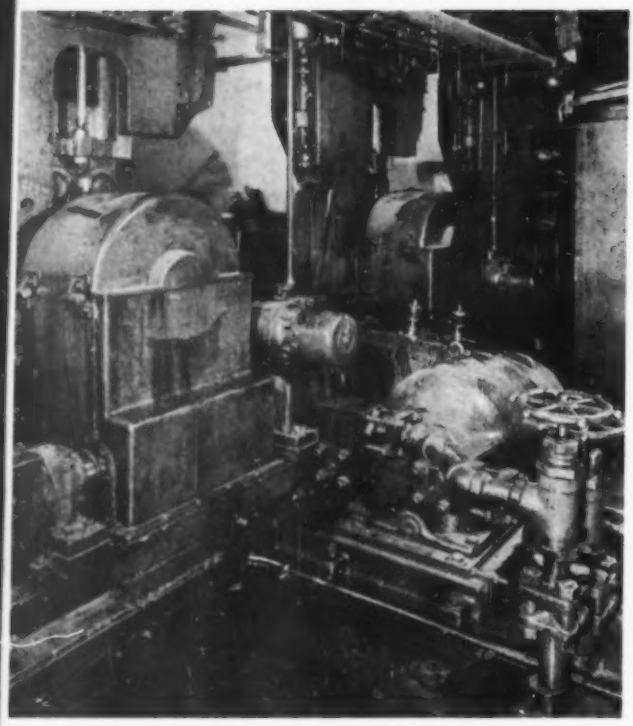
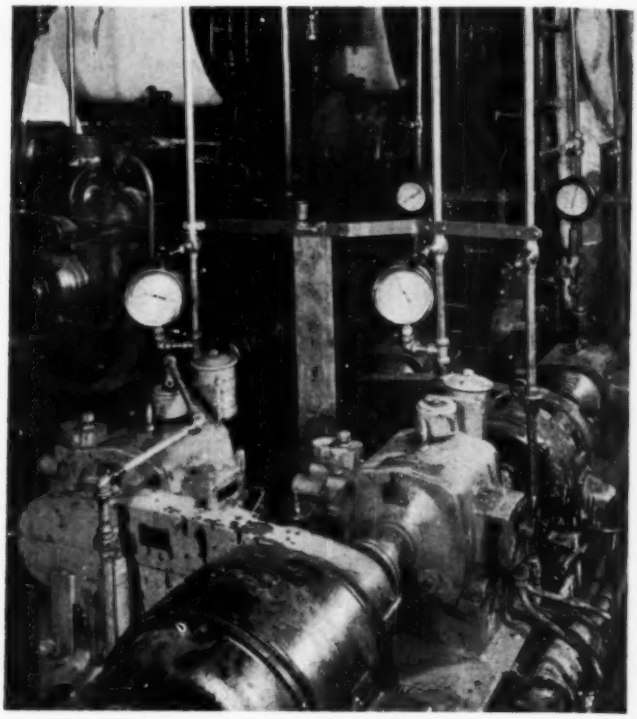


Fig. 1. One of two hydraulic motors for driving a multi-cylinder four-color Scott Rotogravure Press at Neo Gravure Co., Chicago, Ill., subsidiary of Cuneo Press Co.

Fig. 2. Four variable delivery pumps and part of the variable speed drive and hold-down devices for the Scott Rotogravure Press.



Photos Courtesy The Oilgear Company

PRINTING PRESS CONTROL

Neo Gravure Company of Chicago utilizes hydraulic power both for drive and to operate hold-down cylinders of their multi-cylinder four color Scott Rotogravure Press.

Figure 1 shows one of two hydraulic motors for driving the press. Hydraulic drive was selected to provide uniform, smooth acceleration of the press from zero to the desired speed, an important advantage not obtainable from the direct current electric drives in use at the time the hydraulic drive was chosen.

The hydraulic drive eliminates a sparking motor from the pressroom and thus reduces the hazard of fire.

The press ordinarily runs at from 700 to 800 fpm; the fluid power drives providing accurate register over all speeds from 0 to 1000 fpm.

Four variable delivery pumps provide controlled fluid power for hydraulic hold-down cylinders at each end of the press cylinders.

The hydraulic hold-down cylinders were installed to give a uniform and constant pre-determined printing pressure across the cylinder from end to end and to reduce damage to the press in the event that a greater thickness of paper, such as chokes, should pass between the impression roller and the engraved cylinders. Neo Gravure reports that the hydraulic hold-down mechanism has performed very satisfactorily.

Maintenance on the hydraulic drive has been no greater generally than on electric drives. Considerable difficulty was experienced at the beginning in operating and maintaining the Scott press with the hydraulic drive but most of this difficulty was due to inexperience and lack of familiarity with the hydraulic principle. The principal difficulty has been a mechanical one. The limit switch control chains in the control mechanism break from time to time, the hold-down cylinders on each end of a roller are controlled simultaneously.

New PRODUCTS

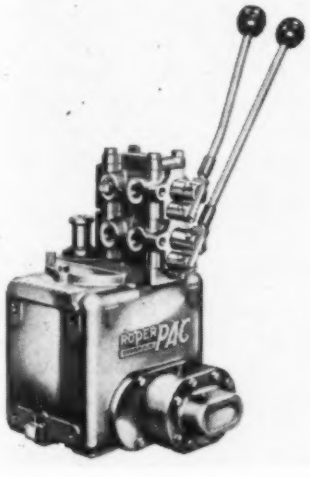
For additional information on any of these products, mark the end key numbers on the card bound in this issue and mail the card.

Solenoid Valve

A 110 v, a-c solenoid two-way valve is offered by Electrol, Inc. Designed for continuous duty on machines utilizing pressures to 1500 psi or higher, the valve is available in ⅛, ¼, ⅜ and ½ in NPT. Use the Business Reply Card, mark NP-20.

Hydraulic Power Unit

Geo. D. Roper Corporation is announcing their Series 1400 Roper-PAC Hydraulic Power Unit for farm equipment. The design features a new valve design and two pump speed ranges of 250 to 500 and 500 to 1000 rpm. A minimum capacity of 4½ gpm at normal operating pressure of 800 psi and a maximum of 1000 psi are obtainable. Roper Bulletin No. 16 contains data on unit application and additional equipment. Use the Business Reply Card, mark NP-21.

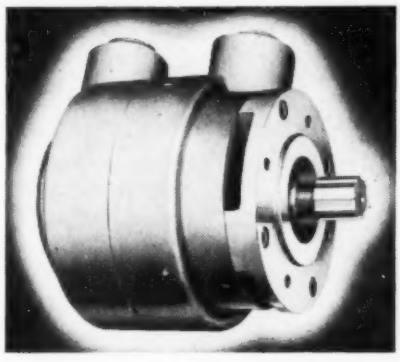


Tube Coupling

The Parker Appliance Co., announced their flareless coupling, Ferulok, for heavy wall tubing. The Ferulok consists of a body available in a variety of shapes, and a nut which forces the ferrule or sleeve to grip the tube. Use the Business Reply Card, mark NP-22.

Vane Pump

Dudco Products Company have announced their vane-type pump for hydraulic oil power applications. The pump is hydraulically balanced for pressure and flow, eliminating hydraulic loads on the bearings.



Operating at 1200 or 1800 rpm and pressures to 3000 psi, available capacities are from 2 to 18 gpm. Also available are the larger series pumps to 60 gpm, and fluid motors to 80 gpm. Use the Business Reply Card, mark NP-23.

Hydraulic Cylinder

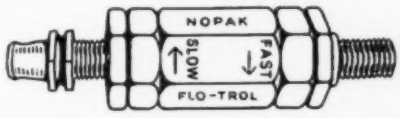
An oil hydraulic cylinder for 1500 psi service on machine tool applications is announced by Bristol Machine Tool Co. Incorporating a built-in, self-adjusting cushion in each end, the basic cylinder can be furnished in nine standard mountings, with the use of simple attachments. Use the Business Reply Card, mark NP-24.

Coupling

A coupling that seals automatically when disconnected, is announced by The Hansen Mfg. Co. Known as Series 8000, the coupling combines two-way shut-off with connecting and disconnecting on either hydraulic or pneumatic lines. Use the Business Reply Card, mark NP-25.

Speed Control Valve

A new Flo-Trol Speed Control Valve is the latest addition to the line of hydraulic equipment offered by Galland-Henning Manufacturing Co.



Developed to give machinery builders and users a speed control valve which is easily and accurately adjustable, the adjusting sleeve is readily turned and set by hand. The Flo-Trol valve may be used in air or hydraulic lines, its compact "in-line" design can be utilized wherever space limitation is encountered. Use the Business Reply Card, mark NP-26.

Pump Unit

Baker Brothers, Inc., have announced a detachable hydraulic pump unit. The feed, return and neutral cycle are electrically controlled. The unit is portable and mounted on caster wheels. Use the Business Reply Card, mark NP-27.

Flow Regulator

An automatic flow regulator for hydraulic systems is announced by Waterman Engineering Co. Unlimited flow in one direction with provision for a predetermined rate of flow in the opposite direction assures against sudden release of hydraulic pressure. Use the Business Reply Card, mark NP-28.

Piston Pump

A piston type pump utilizing four horizontally opposed pistons reducing pulsations to a minimum and operating satisfactorily in either direction has been announced by Miller Hydraulic Engineering & Sales.

Relief valves built into the pump are set to the desired pressure at the factory. Discharge pressures range from 0 to 3000 psi at 1200 rpm with a delivery of 5.4 to 3.0 gpm. Use the Business Reply Card, mark NP-29.

Air-Hydraulic Press

Bryant Products Company has announced an air-hydraulic press for light forming, riveting and assembly operations. Capable of exerting 900 lb on the down stroke, the press features controlled ram speed and pressure. A three-way hand or foot valve, and air line regulator are standard controls with provision for automatic operations of the press by a solenoid valve

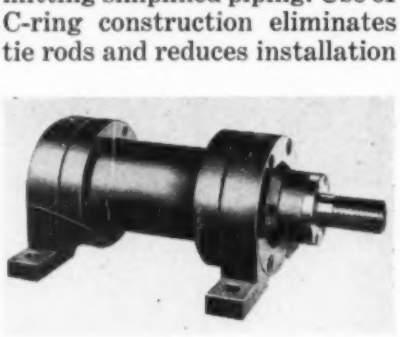
which controls the length of stroke. Use the Business Reply Card, mark NP-30.

Tube Fitting

Brockway Co. have designed a two-piece self-flaring tube fitting. The Uniflare fitting consists of a nut, body and a thrust collar which serves as an extrusion means; wrench pressure shears the thrust collar from the nut when force is applied. Range of sizes are $\frac{1}{8}$ to $\frac{3}{4}$ in. Use the Business Reply Card, mark NP-31.

Hydraulic Cylinders

An improved line of oil hydraulic cylinders for 1500 psi service is being offered by the Air and Hydraulic Division of Lindberg Engineering Company. Ports can be positioned to suit particular applications permitting simplified piping. Use of C-ring construction eliminates tie rods and reduces installation



space. Use the Business Reply Card, mark NP-32.

Rotary Pump

Series S-125 rotary pump was announced recently by Pump Div., Ellipse Corp. Capable of 2.5 gpm delivery at 1000 psi, utilizing vanes and rotor, it is nonpulsating and may be run in either direction. Use the Business Reply Card, mark NP-33.

Limit Switch

Industrial Controller Div., Square D Co., has announced a precision limit switch for machine tool applications. This is available with roller-arm or push-rod operated mechanisms. A 180 degree rotation of the cover and switch assembly reverses the $\frac{1}{2}$ in conduit opening. Use the Business Reply Card, mark NP-34.

Hydraulic Filters

Two models of filters recommended for the hydraulic field have been announced by General Filters, Inc. Based on the Full-Flow principle, the filtering

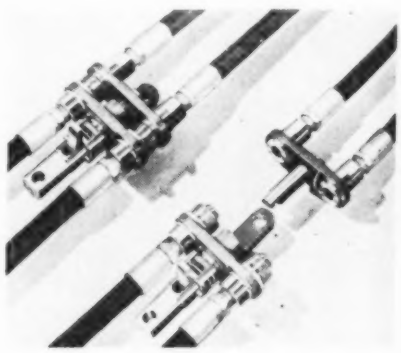
element is constructed of special wool felt, maintaining a high rate of flow while removing smaller size solids. Moisture and dirt may be removed from the filter element by putting the element through a degreaser. The model AF-400 has a by-pass set at 15 psi, while the model AF-500 has no by-pass. Use the Business Reply Card, mark NP-35.

Power Unit

A fully self-contained hydraulic power unit is now manufactured by Hufford Machine Works. The unit includes motor, pump, valves and flow control mounted on a reservoir base in which there is a filter system. The selector valves provide for reversible flow for any hydraulically operated machinery. Use the Business Reply Card, mark NP-36.

Hydraulic Coupling

A "Breakaway" coupling for use in the hydraulic operation of farm implements is an-



nounced by Aeroquip Corporation. Installed in the hydraulic lines between the tractor and implement the coupling automatically disconnects whenever the implement accidentally becomes unhitched. Use the Business Reply Card, mark NP-37.

Hydraulic Transmission

A small hydraulic variable-speed transmission is available from Portman Machine Tool Co. Providing infinitely variable speeds from neutral or zero to full electric motor speed, either forward or reverse, Model T-1 has a rating up to 1 hp. Use the Business Reply Card, mark NP-38.

Check Valve

Mansfield & Green have announced a doubly-sealed check valve designed to eliminate loss

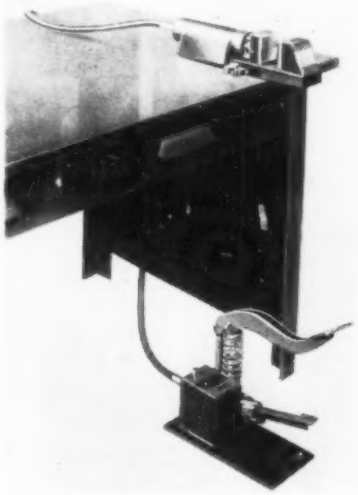
of pressure and leakage. With a pressure range to 10,000 psi, the valve is available in sizes ⅛ to 1 in standard pipe thread. Use the Business Reply Card, mark NP-39.

Reversing Valve

Announcement of a reversing valve has been made by R. I. Task Enterprises, Inc. The "Rite" a four-port valve for hydraulic cylinder actuation obtains its full reversal movement from the cylinder itself. Use the Business Reply Card, mark NP-40.

Hydraulic Vise

A foot-powered hydraulic vise is announced by Munton Manufacturing Co. Designed to eliminate tedious manual cranking, it enables the worker to keep both hands on his job.



Capable of a 2-ton holding pressure, it may be used on a milling machine, drill press or bench. Use the Business Reply Card, mark NP-41.

Pumping Unit

A hydraulic pumping unit designed to actuate rams on automotive or tractor equipment has been announced by John Dusenbery Co. Also applicable to machine tools, ram force of 2500 lb at a rate of 1 in per sec with maximum out put of 46 cu in Use the Business Reply Card, mark NP-42.

Fittings

A self-flaring fitting for tubing, the Everseal, has been announced by Everhot Products Co. A leak-proof flare is claimed through the simple, single operation of assembling the fitting to the tubing. Use the Business Reply Card, mark NP-43.

Flexible Coupling

The Climax Type C flexible coupling, for light duty installations and use with electric motor drives only, is available from The Climax Flexible Coupling Co. Made in three parts, two identical metal hubs and a load-carrying rubber insert, the coupling has a high flexibility and good shock absorption capacity. The six sizes of couplings range from 1/3 to 12 hp. Use the Business Reply Card, mark NP-44.

Hydraulic Cylinders

A new line of hydraulic cylinders is announced by National Hydraulic Co., Inc. The full line of Natdraulic cylinders offers seven standard mountings with bore sizes from 1 to 12 in, with any length of stroke, pressures to 1500 psi and a 5-1 safety factor. Use the Business Reply Card, mark NP-45.

POST SCRIPTS OF INDUSTRY

NEWS · VIEWS · TRENDS

A merger of three control instrument companies, Robertshaw Thermostat Co., Youngwood, Pa., the Fulton Sylphon Co., Knoxville, Tenn. and the Bridgeport Thermostat Co. of Bridgeport, Conn., under the organization name of Robertshaw-Fulton Controls Co. has been announced. The new firm's headquarters will be at Knoxville, Tenn.

The Chicago Pneumatic Tool Co. will build a new plant in Utica, N.Y. this spring. Construction is expected to begin in March or April. The plant will have over 500,000 sq ft of floor area and will employ approximately 2000 persons.

Bailey Meter Co., Cleveland, announces the appointment of G. R. Mays as manager of its St. Louis branch to replace L. E. Evans, resigned.

The Oil and Gas Division, American Society of Mechanical Engineers will meet May 20-22 at the Jefferson Hotel, St. Louis.

The Parker Appliance Co. has appointed B. W. Rogus Co., Akron, Ohio, as distributor for tube fittings and valves.

Giddings & Lewis Machine Tool Co., Fond du Lac, Wis., announces the promotion of Donald M. Laflin to assistant general sales manager. Laflin's previous post was eastern district sales manager.

The Apparatus Department of General Electric Company has added the Elmira Foundry Co., Inc., of Elmira, N.Y., as its ninth major works unit. Ralph H. Roberts remains as manager of the new unit.

According to Exhibitors Advisory Council, Inc., New York, 1948 will see a record number of trade shows and exhibitions. Already listed for the first 8 months are 718 trade, industrial and professional events, an increase of 53 percent over the 468 in the same period of 1947.

The Instrument Society of America will hold their third conference and exhibit Sept. 13-17 in Convention Hall, Philadelphia. Several related societies will participate in the technical sessions.

ASTE INDUSTRIAL EXPOSITION to meet in Cleveland

The Sixth Annual ASTE Industrial Exposition will be held in Cleveland, March 15-19, 1948, coincident with the society's sixteenth annual meeting, according to an announcement by the general policy committee of the American Society of Tool Engineers.

William Bradford Pierce, President of the ASTE, states that exhibit space already sold guarantees that this exposition will be the largest in the society's history.

Admission is by invitation only, facilitating contacts between visitors and exhibitors, which is the real reason for this show, Mr. Pierce said.

The tentative program for the Exposition will include plant tours, group technical meetings and a formal banquet.

The Exposition is expected to bring more than 50,000 key industrialists to Cleveland, according to Harry E. Conrad, Executive Secretary of the Society.

Technical sessions and plant tours will form an important part of the Convention program, which will feature James D. Mooney, president and chairman of the board of Willys-Overland Motors, as guest speaker at the annual banquet to be held in the ballroom of the Hotel Carter, Thursday evening, March 18.

The technical sessions will be devoted to subjects designed to aid in increasing production and will consist of discussions of important phases of production problems by recognized leaders.

Tours of plants in the Cleveland area have been arranged so that tool engineers and other Exposition visitors will have an opportunity to observe a wide variety of industrial operations. Plants that will be open to Exposition visitors include The Warner & Swasey Co., The Ohio Crankshaft Co., The White Motor Co., Fisher Body Division of General Motors Corporation, The National Acme Co., General Electric Co. (Nela Park), The Weatherhead Co., The Reliance Electric and Engineering Co., Republic Steel Corporation (Strip Mill), Jack and Heintz, Precision Industries, Inc., and the Laboratories of the National Advisory Committee for Aeronautics.

A Partial List of Exhibitors at the Tool Show

The Aro Equipment Corporation . . . Bryan, Ohio . . . Booth No. 725

Barnes Drill Co. . . . 814 Chestnut St., Rockford, Illinois . . . Booth No. 619

The Bellows Company . . . Ralph Gross Advertising . . . 109 North Union St., Akron 4, Ohio . . . Booth No. 1010

Chicago Pneumatic Tool Company . . . 6 E. 44th St., New York 17, N. Y. . . . Booth No. 1527

Cincinnati Milling & Grinding Machines, Incorporated . . . Cincinnati 9, Ohio . . . Booth No. 1427

Cities Service Oil Companies . . . 70 Pine St., New York 5, N. Y. . . . Booth No. 1622

The Denison Engineering Company . . . 1160 Dublin Rd., Columbus 16, Ohio . . . Booth No. 1207

Federal Products Corporation . . . 1144 Eddy St., Providence 1, Rhode Island . . . Booth No. 314 and 413

Flodar Corporation . . . 331 Frankfort Ave., Cleveland, Ohio . . . Booth No. 925

Gerotor May Corporation . . . Baltimore 3, Maryland . . . Booth No. 1422

Hanna Engineering Works . . . 1765 Elston Ave., Chicago 22, Illinois . . . Booth No. 1219

Hannifin Corporation . . . 1101 S. Kilborn Ave., Chicago 24, Illinois . . . Booth No. 714 and 813

C. B. Hunt & Son, Incorporated . . . 1913 E. Pershing St., Salem, Ohio . . . Booth No. 822

Lincoln Engineering Company . . . 5701 Natural Bridge Ave., St. Louis, Missouri . . . Booth No. 1540

Lindberg Engineering Company . . . 2450 W. Hubbard St., Chicago 12, Illinois . . . Booth No. 909

Logansport Machine Company, Inc. . . . Logansport, Indiana . . . Booth No. 1537

Micro Switch . . . Div. of First Industrial Corp. . . . Freeport, Illinois . . . Booth No. 127

Miller Motor Company . . . 4027-33 N. Kedzie Ave., Chicago, Illinois . . . Booth No. 1516

Racine Tool & Machine Co. . . . State & Carlisle Ave., Racine, Wisconsin . . . Booth No. 417

A. Schrader's Son Division . . . 470 Vanderbilt Ave., Brooklyn 17, N. Y. . . . Booth No. 1807

The Sheffield Corporation . . . 721 Springfield St., Dayton 1, Ohio . . . Booth No. 826 and 830

Shell Oil Company, Inc. . . . 50 W. 50th St., New York 20, N. Y. . . . Booth No. 1521

The Sinclair-Collins Valve Co. . . . Akron, Ohio . . . Booth No.

The Skinner Chuck Company . . . New Britain, Connecticut . . . Booth No. 801

Snyder Tool & Engineering Co. . . . 3400 E. Lafayette Ave., Detroit, Michigan . . . Booth No. 208

Socony-Vacuum Oil Company, Inc. . . . 26 Broadway, New York 4, N. Y. . . . Booth No. 1409

Standard Gage Company, Inc. . . . 70 Parker Ave., Poughkeepsie, N. Y. . . . Booth No. 302

Taft-Peirce Mfg. Company . . . 32 Mechanic Ave., Woonsocket, Rhode Island . . . Booth No. 329

POST SCRIPTS OF INDUSTRY

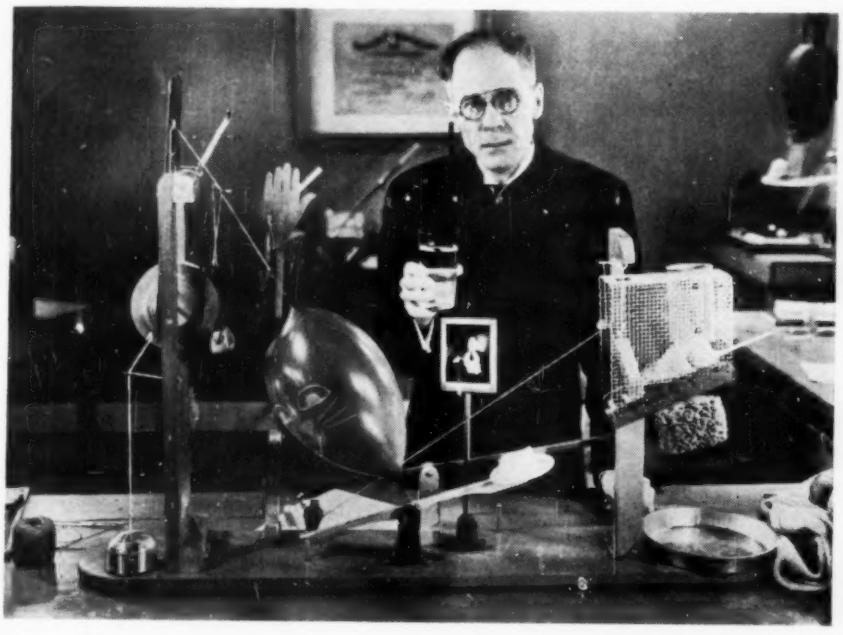
(Continued from page 33)

The 17th annual Packaging Exposition of the American Management Association will open April 26 in Cleveland's Public Auditorium and continue through the 30th.

The annual three-day conference on Packaging, Packing and Shipping of the AMA, concurrent with the exposition, will also be held in the Auditorium April 27-29. Packaging executives, engineers and technical experts will discuss materials, methods, procedures and merchandising.

Approximately 200 exhibitors will display developments in packaging, equipment, materials, packing and shipping machinery, design and services used in the manufacture and sale of virtually every product in the nation's commerce.

The annual Conference and Exposition of the National Association of Corrosion Engineers will be held April 5-8 at the Jefferson Hotel, St. Louis.



THE HYDRAULIC CIGARETTE LIGHTER

NEED A LIGHT? AND A LAUGH?

Learned men agree that civilization began when men learned how to use fire. Most men still carry devices of various and dubious merit around with them to practice starting fires. The cigarette is merely the favorite excuse for this arsonous habit. For the man with such a repressed desire and for the smoker who wishes to cut down his smoking a revolutionary new hydraulic lighter is now available.

This ingenious lighter utilizes the unrelated laws of mechanics and of hungry rats as no machine designer ever did, and according to the inventor who is pictured with his pilot model, it has never failed. The inventor Professor Oakes, the famous "Wizard of Waukesha", is shown about to use the latest of his inventions, his hydraulic cigarette lighter. He will pour a glass of water into a receptacle at the right. The water will run down on a sponge, which as it becomes heavy sinks, raising the opposite end of the lever which will open the gate of the rat's cage (he specifies that the rat be female). She leaps out for the cheese placed on one end of another lever. (EDITOR'S NOTE: this is as far as we could verify the operation since the rats we caught grabbed the cheese and took off in high gear.) The Professor stoutly maintains that a properly trained female rat would not run away. If the rat did not run away, the machine would, strictly according to the Professor, finally produce a light for the cigarette in the dummy hand. Unfortunately, the Professor has forgotten how he put the hydraulic lighter together and he has been demonstrating it before audiences of technical men in the hope that someone would understand the lighter well enough to write his patent application for him.

Through an agreement between the Western Society of Engineers and the John Crerar Library a technical and scientific center has been established in Chicago. Three floors in the Taylor Building adjoining Crerar Library on Randolph street have been leased. Included in the center will be offices, conference rooms and an auditorium capable of seating 300 persons. The Western Society's collection of 20,000 books will be co-ordinated with the 700,000 volume Crerar Library, the world's largest free public library devoted exclusively to science and technology.

BOOK REVIEW

"A Handbook on Synthetic Rubber packings", *prepared by the Hydraulic Engineering Department, E. F. Houghton & Co., Philadelphia. First Edition, 110 pages, 6 x 9 inches.*

This handbook is published for the information and convenience of hydraulic engineers. Application and design characteristics of fabricated "V", "U", cup and flange packings; for homogeneous "V", "U", "O" ring, cup, flange, diaphragms, wipers and special shapes are listed and described. Leather back-up washers for "O" ring packings and gaskets for pressures over 1500 psi are treated in a separate chapter in some detail. Leather back-up washers for synthetic rubber gaskets (AN-902) for pressures above 1500 psi are also described. The handbook is profusely illustrated with drawings and photographs that give numerous installations and maintenance suggestions and hints. Many tables and a final chapter on reference data add to the practical value of the handbook.

CREDIT

The photograph of the Reeves Transmission, page 46, February issue, was furnished by Resistoflex Corporation; data on the servo by J. H. Gepfert, Div. Mgr., Reeves Pulley Company, Cleveland, Ohio.

Useful Literature

The publications listed are available without charge. Mark the initial key number on the card bound in this issue and mail.

26. Pump and Valve Bulletin ... Racine Tool and Machine Co. is offering an 8-page bulletin describing their variable volume hydraulic pumps, valves and pressure booster. Three sizes of pumps and five sizes of pressure boosters with dimensional drawings are included.

27. Hydraulic Unit ... The description of Twin Ram No. 2000 and 5000 hydraulic units is contained in a bulletin which is available from Le Maire Tool & Manufacturing Co. The wide variety of jobs to which these self-contained power units may be applied is illustrated. Specifications and capacity of the units are included.

28. Hydraulic Cylinders ... The entire line of hydraulic cylinders of Hydro-Line Manufacturing Co. is shown in their catalog H-47 and is available on request. Complete specifications of seven types of cylinders, construction and design, are available in sizes from 1½ to 8 in bore in a variety of mountings.

29. Oil and Fluid Seals ... A 36-page bulletin, Catalog No. 101 is available from National Motor Bearing Co., Inc. Available in sizes ranging from ¼ to 12 in shaft dia, the catalog describes the full line of standard shaft seal designs. Nine special types of seals for miscellaneous application are also listed.

30. Accumulator Booklet ... An authoritative 20-page booklet containing descriptive data on hydraulic accumulators has been published by Greer Hydraulics, Inc. The booklet is intended primarily to acquaint users of fluid power with advantages to be gained by use of accumulators in hydraulic circuit design. Details, principles of operation, performance charts and engineering data are included.

31. Control Bulletin ... Square D Company is offering an 8-page bulletin on their line of control switches. Industrial pressure switches are included for machine tool application with a pressure range from 100 to 3000 psi.

32. Packing Circular ... A circular on leather and synthetic rubber packings is announced by the manufacturer, E. F. Houghton & Co. The "U", "V" and Cup packings are featured for use in hydraulic or pneumatic equipment with pressures to 16,000 psi and temperatures of –70 F to 200 F.

33. Pressure Booster ... A circular on the hydraulic pressure booster is available from Hydro-Power, Inc. Pressure ratios are 2¼ to 1 and 3 to 1. Two sizes are listed, 35 and 100 gpm input, with output in inverse proportion to intake and discharge pressures.

34. Solenoid Valve ... Folder 117, outlining the operation of the "Electroflo Valve", is available from Hays Mfg. Co. Automatic valve control of oil, water, steam or air is obtainable for continuous or intermittent operation. Three selections of piping methods are offered.

35. Feed Pump ... The Oilgear Company has published a new 8-page bulletin 44200 which illustrates and describes their new Fluid Power Variable Delivery Feed Pump. The type "JK" feed pump is available in three models with drive shaft speeds of 860, 1140 and 1750 rpm, with a maximum feed delivery of 110, 150 and 240 cu in per min.

36. Hydraulic Packing ... Catalog "C", of Goshen Rubber & Mfg. Co., contains application and installation data for "O" ring and square section static seals. Included are illustrations of designs for non-extrusion rings and back-up washers.

37. Hydraulic Oil Pumps ... Bulletin 303, issued by Viking Pump Company gives dimensional specifications, six sizes of pumps ranging from 5 to 45 gpm output. Performance and installation data are included.

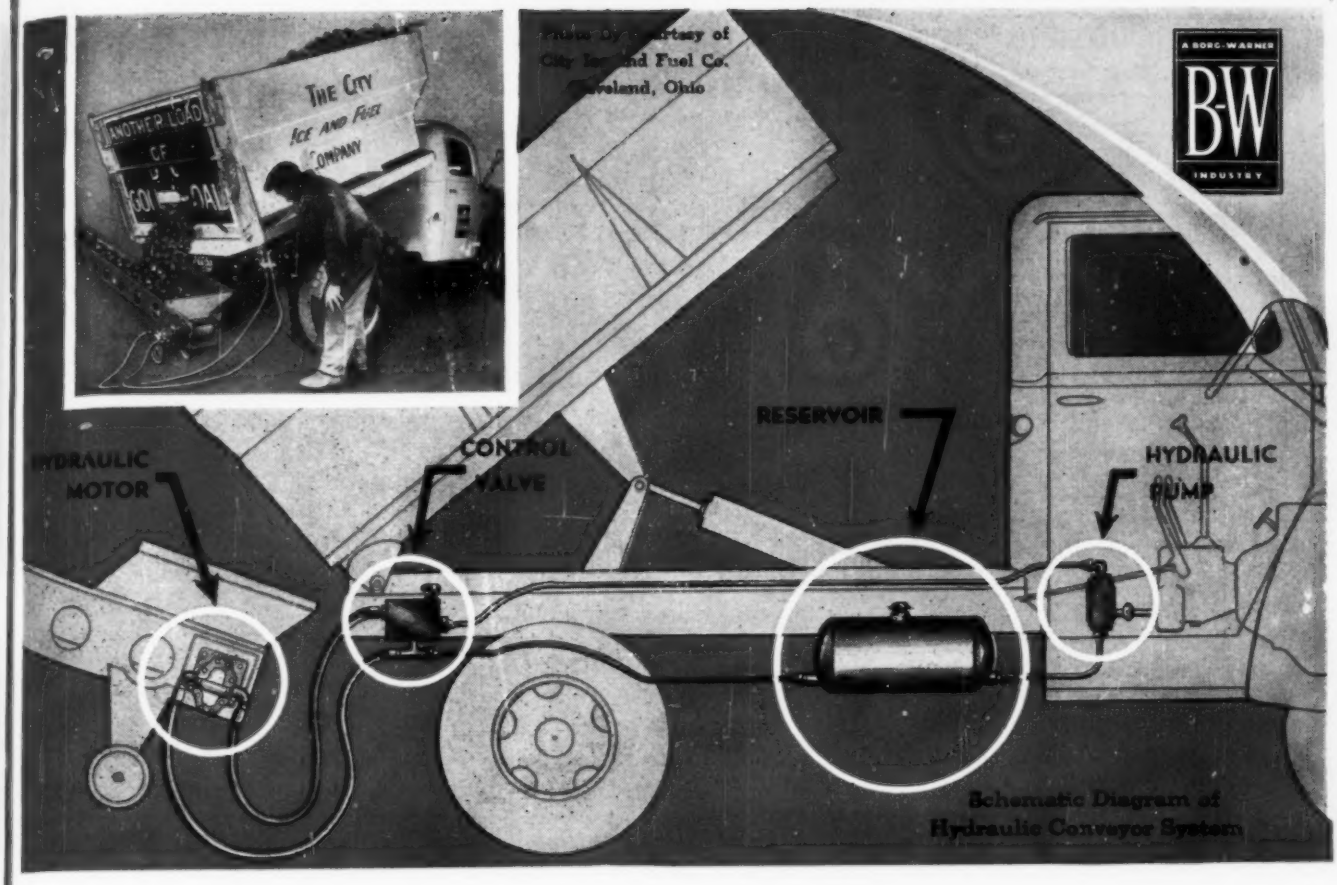
38. Pressure Switch Catalog ... Eight types of pressure switches are discussed in a catalog available from Diaphlex, division of Cook Electric Company. The Cook Hi-Pressure switch is designed for control of high pressure hydraulic, air and steam systems, with a maximum surge to 2500 psi. Available pressure connections are: ⅛, ¼, ⅜, 7/16-20, ½ and ¾ in standard female pipe thread.

39. Synthetic Packings ... A 16-page booklet has just been announced by Acadia Synthetic Products Division of Western Felt Works. Containing specifications of Vee seals and piston cups for both hydraulic and pneumatic installation, the Vee seal is available in ID sizes from 3/16 to 24 in and 5/16 to 15⅜ in OD for cup seals.

40. Air Control Valves ... Logansport Machine Co., Inc., has included their line of Air Control Valves and Accessory Equipment in Catalog 90. The 48-page catalog contains specifications and mounting data of their full line of valves, which include typical circuit diagrams for installation.

41. Shaft Seals ... A 12-page booklet, "Sealing with Certainty", is available from Rotary Seal Company. The design, construction, and application of shaft seals for use in hydraulic pumps, power transmitting equipment, controls, etc. are described. Shaft seals are avail-

(Continued on page 38)



A flexible, hydraulic conveyor system

THAT REDUCES MAINTENANCE AND OPERATING COSTS

Whether your problem is to unload coal trucks outdoors (as illustrated) or convey crushed stone or other materials indoors, this *Pesco* hydraulic system will do the job more efficiently, with less wear and maintenance expense than other systems.

Totally enclosed, there are no working parts exposed to outdoor elements or indoor dust and dirt. No lubrication is needed. The system cannot be damaged by overloads. And because of the flexibility of installation which requires that only the fist-size hydraulic motor be a part of the conveyor the Pesco hydraulic system is particularly adapted to conveyors where space is limited. Speed reduction is easily accomplished without complicated, bulky equipment.

The *Pesco* hydraulic system consists of:

PUMP—the famous Pesco hydraulic pump that features "Pressure Loading" . . . high over-all efficiencies . . . automatic take-up for wear . . . long, trouble-free life.

MOTOR—the *Pesco* hydraulic motor that is non-stalling . . . features 90 percent starting efficiency . . . and has minimum service requirements.

VALVE—the *Pesco* control valve regulates conveyor speed . . . insures selected belt speed regardless of variations in load or pump speed . . . acts as a relief valve in case of overloads.

There are many additional outstanding features of this Pesco hydraulic system. All units are available in a wide range of sizes to meet all requirements. For complete information regarding use of the system for truck unloading conveyors or for permanent outdoor or indoor conveying systems, write today to Department 4-2. There is no obligation whatsoever for this service.

Pesco PRODUCTS DIVISION
BORG WARNER CORPORATION
11610 Euclid Ave. · Cleveland 6, Ohio

MANUFACTURERS OF B-W SUPERCHARGERS

USEFUL LITERATURE

(Continued from page 36)

able in sizes ranging from .187 in to 5.500 in dia.

42. Relay and Timer Catalog . . . A 48-page catalog on controls, time delay and magnetic relays and solenoids is available from Struthers-Dunn, Inc. Catalog F describes the general features, contacts, data and selection and applications of their full line of relays and timers.

43. Fittings Catalog . . . Catalog 4-R describing the Superseal flared fittings is available from Grinnell Company, Inc. Available for tube sizes of 3/16 to ⅝ OD the fittings are made in male, female and double flare adapter, 90 degree elbow and Tee shapes. Dimensional data of the fittings are included.

44. Hydraulic Pump Circular . . . Pesco Products Division, Borg-Warner Corporation have available a circular outlining their General Purpose Hydraulic Pump. Included are performance facts, installation diagram and chart of horsepower requirement.

45. Hydraulic Equipment Catalog . . . Sundstrand Pump Division, Sundstrand Machine Tool Co. has available a catalog on design, engineering and performance data of Sundstrand Hydraulic Equipment. Data on their full line of pumps, variable speed transmissions and solenoid valves with line drawings and specifications are included.

46. Hydraulic Handbook . . . Bulletin 50, Hydraulic Handbook, is now available from The Aldrich Pump Co. The first section of the 60-page booklet, contains hydraulic definitions, formulas and engineering information, the remaining sections are devoted to Aldrich facilities and products respectively.

47. Hydraulic Transmission Bulletin . . . Vickers, Incorporated has available Bulletin No. 47-40, which outlines the features of their series TR2, variable speed hydraulic transmission. The transmission is equipped with handwheel or servo control, adjustable from zero to maximum rpm in either direction, with a maximum output torque of 40 pound inches available throughout the entire speed range.

48. Oil Purifiers . . . The Hilliard Corporation has issued a general catalog on their full line of purifiers, reclaimers and filters for use in hydraulic systems and industrial equipment. Specifications and installation data are included.

A VERY LIGHT TOUCH!

(Continued from page 18)

simple, being essentially holding fixtures for the contact and bridge parts. At present we are running seven different assemblies on the press using four sets of dies and three sets of adaptors. These adaptors are interchangeable die parts which our Tool and Die Department built to enable us to make quick changes in running similar, but not identical, types of assemblies, one right after another. To change a complete set of dies on the index stations would require about two hours of top skill time; the adaptors made it possible to change from one type of contactor assembly to another in a matter of minutes.

A critical factor in assembling contacts of the type illustrated, Fig. 1, was the pressure. Actual pressures required to set the contacts firmly in the bridges ran from 500 to 700 pounds and never over 1000 pounds. This is relatively a very light pressure but it was adequate to give us the 90 percent metal to metal contact which our inspection set as standard. Further, it is essential that the pressure be very uniform, since even small variations would result in minute distortions of the contact head and springback of the bridges. Pressure variations would mean scrapping of finished assemblies.

Literally, we required a very light touch to make precision contact and bridge assemblies. Hydraulic operation gave us the accuracy of control over the pressure exerted by the descending ram, which was essential.

Dies are installed on all six stations. If we count the loading station as the number one station, stations two, three and four are open stations on which the operator manually completes the loading; station five is the ram or working station and station six is the unloading or ejector station. The table moves clockwise, so that the operator has ample time to place the bridge members over the contacts on the male die.

Another factor which was important to us was that the operator considered the job more interesting; that while her hands were kept busier, the press and index table were much quieter, safer and easier to operate than our previous equipment.

With the equipment setup as described, we have been able to increase production of contact and bridge assemblies from an average of 240 or 250 per hour to 800 to 900 per hour. The scrap problem which had been a problem, has virtually been eliminated. The net gain in production has been better than 3 to 1 over the prior method employed.

The press and index table are kept setup with one or another of our contact assembly jobs. Due to the increased rate of production, the runs which average 20,000 sets of assemblies, actually have kept well ahead of our own requirements in making final assemblies of our equipment.

The development of this improved production setup has been due to the excellent cooperation between the Methods and the Tool and Die Departments in our company. The hydraulic equipment for our contact and bridge assembly jobs was selected on the basis of the advantages which it offered—speed with accuracy and ease of control, adaptability and positively controlled sensitivity of pressure which gave us that very light touch.

PERSONALS

BERNARD LESTER, after being associated with Westinghouse Electric Corporation for 43 years, retired January 31. Mr. Lester was assistant manager of Industrial Sales. He is opening a consulting service emphasizing sale and distribution of machinery and equipment to managers of medium-sized and small industrial equipment builders and suppliers. Mr. Lester became a pioneer in the training of industrial salesmen and developed and taught the first formal college course given in "Selling Industrial Equipment" at the Graduate School of the University of Pittsburgh.

Bernard Lester

L. B. SMITH, vice president and director of the A. O. Smith Corporation, Milwaukee, has been designated as general manager of the company's Kankakee Works.

J. E. FLICKINGER, formerly in charge of aircraft sales for the western territory of Saval Company, has been promoted to sales manager according to an announcement by L. S. Barksdale, Saval president. During the war he was overseas as technical observer for Allied Air Forces. Prior to joining Saval Company, Flickinger was associated with American Air Lines as aircraft procurement supervisor.

J. E. Flickinger

JOHN D. GORDON, vice president and general manager of Progressive Welder Company, Detroit, has announced the appointment of Joseph R. Lex as assistant general manager. Mr. Lex, a graduate of the University of Munich, joined Progressive early in 1946 and has been active in both sales and engineering of the company's line of resistance welding equipment.

L. W. HAYDEN has been appointed resident vice president of Lindberg Engineering Co., and will be in charge of all east coast sales offices as well as all export sales. His headquarters will remain in New York. G. W. Helsberg is now in charge of the Boston office, having transferred from the New York office; and R. W. Dougherty, formerly in charge of the Kalamazoo, Michigan office will be in charge of a new office in Philadelphia, being replaced at the Kalamazoo office by T. M. LaCrone. S. K. Oliver will be attached to the Cleveland office, transferring from New York.

E. B. MAIRE, formerly regional sales manager for General Controls Co., Glendale, Calif., has been recently appointed sales manager of the midwestern, southern and eastern branch offices.

ROGER G. DeLONG, formerly sales manager and acting manager of the Rockford division, has been appointed manager of the Hydraulic Division, Twin Disc Clutch Co. W. B. Gibson, who has been assistant district manager of the eastern territory of the company, was named sales manager at the same time.

E. G. BAILEY, vice president and director of Babcock & Wilcox Co. of New York was elected president of ASME at the 68th annual meeting held at Atlantic City in December. Mr. Bailey is the founder of the Bailey Meter Co. of Cleveland.

JOSEPH R. LEX, was recently appointed assistant general manager as announced by John D. Gordon, vice president and general manager of Progressive Welder Company, Detroit. Mr. Lex, a graduate of the University of Munich, joined Progressive early in 1946 and has been active in both sales and engineering of the company's line of resistance welding equipment.

Joseph R. Lex

J. F. ROBERTS, manager hydraulic turbine department, Allis-Chalmers Mfg. Co., Milwaukee, was recently reelected chairman of the hydraulic turbine section, National Electrical Manufacturers Association.

GEORGE L. ZIEGLER, with the Worthington Pump & Machinery Corp., since 1925, has been appointed assistant to the manager of the company's Buffalo works. He had been assistant chief engineer of the engine division.

FARREL B. WEBER has been appointed to the position of sales manager by Micromatic Hone Corporation of Detroit. Formerly with Westinghouse Electric Corporation, he has been with Micromatic since January 1945 and assisted in the development of machine tool electrical systems and electronic controls for automatic sizing.

Farrel B. Weber

H. MERRILL BOWMAN has been named by the Link-Belt Company, Chicago, as assistant divisional sales manager for power transmission equipment. Eugene S. Bogard has been transferred from the Pittsburgh office to the Baltimore office where he will serve as district sales manager.

GEORGE CHINN, chief engineer, Gerotor May Corp., spoke recently before the Columbus, Ohio Chapter ASTE on "Hydraulics for Industry". Mr. Chinn touched briefly on many phases and possibilities of hydraulic equipment for control of power applications and emphasized the vastness of the hydraulic field.

DR. WARREN E. WILSON has been appointed director of research of the Hydraulic Division of Sundstrand Machine Tool Co. Dr. Wilson studied in the graduate schools of both the California Institute of Technology and University of Iowa, and received his Ph.D. from the latter institution. He was head of the Department of Mechanics and Hydraulics at the Colorado School of Mines, and during the war was Chairman of the Department of Fluid Mechanics at the Armour Research Foundation. Dr. Wilson was active as a consulting engineer, before joining the staff at the Sundstrand Machine Tool Co.

RICHARD H. DIESEL has been appointed assistant general sales manager of the Stamford Div., The Yale & Towne Manufacturing Co.

FREDERICK C. CRAWFORD, president of Thompson Products, Inc., Cleveland, was named chairman of the Ordnance Committee of the Research & Development Board, National Military Establishment.

THOMAS L. HALLENBECK, formerly research engineer, has been promoted by Baker Brothers, Inc., to vice president and director of engineering.

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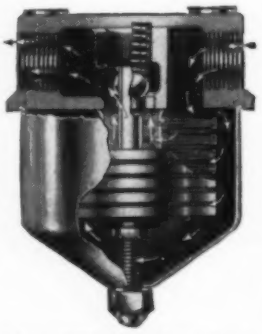

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The Filter Engineers

DIGEST

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The selection or proper values to produce the desired attenuation characteristics is explained by the use of these charts and attenuation diagrams.

Cabin Supercharger Design and Drive Systems

S. B. Sherwin and D. O. Moeller, *SAE Preprint,* January 1948, 8 pp.

A description of a fluid-drive coupling for a plane cabin supercharger. Oil pressure in the fluid-drive controls the impeller speed and therefore the air flow. Oil outflow is controlled by a valve which senses pressure differential in a venturi through which the cabin air passes.

Rotary Valve Controlled Pneumatic Hammer

Anonymous, *Product Engineering,* v 18, November 1947, pp 94-95.

The cycle of operation of a rotary valve for the control of the pneumatic hammer made by Erie Foundry Co., is shown by an elevation drawing and eight detail sketches of each position in the operating cycle.